Risk, Systems and Decisions

Andrew V. Wister
Theodore D. Cosco *Editors*

Resilience and Aging

Emerging Science and Future Possibilities

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Editors
Andrew V. Wister
Simon Fraser University
Gerontology Research Centre
Vancouver, BC, Canada

Theodore D. Cosco
Simon Fraser University
Gerontology Research Centre
Vancouver, BC, Canada

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Preface

This volume drew out of a conference—the John K. Friesen Lecture Series held at Simon Fraser University, June 10 and 11, 2019, entitled, "Understanding and Fostering Resilience in Older Adults." Our intent was to bring together a group of international experts conducting research in the expanding interdisciplinary field of resilience and aging. The 12 chapters comprising *Resilience and Aging: Emerging Science and Future Possibilities* represent cutting-edge research in an emerging area of inquiry. Indeed, the study of how and why some older people bounce back from adversity better than others or better than expected has grown exponentially in importance. The COVID-19 global crisis has magnified the relevance of elucidating the risk, response, and resilience of older individuals, their families, communities, and the complex systems in which they are embedded. This crisis has unleashed unprecedented levels of adversity, especially for older populations, in what has become a "gero-pandemic," especially for vulnerable older adults who are the most affected in terms of infection risk, negative health effects, and the potential deleterious outcomes on a range of social, psychological, and economic contexts. It has also underscored the relevancy of resilience models and applications for a range of often intersecting adversities.

The development of knowledge in resilience and aging at the theoretical, conceptual, and methodological level has reached a watershed, whereby applications to a variety of substantive problems can be manifested. It is intended that the knowledge contained in this monograph will be useful to researchers, policy makers, and students interested in aging and resilience processes from a multitude of perspectives and disciplines as well as supporting multidisciplinary and transdisciplinary research.

Vancouver, BC, Canada

Andrew V. Wister
Theodore D. Cosco

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About the Editors

Andrew V. Wister, PhD is Director of the Gerontology Research Centre at Simon Fraser University and Professor in the Department of Gerontology, where he spearheaded the development of the Master's and PhD programs. He is an internationally recognized expert on aging issues, policies, research, and training. Dr. Wister has written extensively on healthy aging and health promotion. Substantive areas of research include baby boomer health dynamics, population aging and population health, resilience and aging, social isolation, and environmental adaptation among older adults. His research adopts an interdisciplinary approach, utilizing multiple methods, including mixed-methods, in order to disentangle the inherent complexity of aging over the life course. Dr. Wister has also been active in the Canadian Association on Gerontology, receiving the Distinguished Member Award in 2014, and is past Chair of the National Seniors Council of Canada. As the Lead on the Simon Fraser University Data Collection Site and Computer Assisted Telephone Interview Site, Dr. Wister is an active core member of the Canadian Longitudinal Study of Aging (CLSA).

Theodore D. Cosco, PhD began volunteering at age 12 at a long-term care facility, beginning what would become a life-long passion for gerontology and the aging process. Using both qualitative and quantitative approaches, Dr. Cosco examines a range of factors that promote healthy aging and resilience in older adults, from digital interventions to physical activity. He is an Assistant Professor in the Department of Gerontology, Simon Fraser University, and is a Research Fellow at the Oxford Institute of Population Ageing, University of Oxford. Dr. Cosco is a Chartered Psychologist (British Psychological Society) trained in applied social research methods (MSc, Trinity College Dublin) and epidemiology (PhD, University of Cambridge). Recently, he received the Early Career Achievement Award from the American Psychological Association and European Health Psychology Society, as well as becoming the youngest recipient of the Canadian Association on Gerontology's Recognition Award for Excellence in Longitudinal Research in Honour of Betty Havens.

Introduction: Perspectives of Resilience and Aging

Andrew V. Wister and Theodore D. Cosco

Abstract This chapter provides a rationale for the theme of this book, an overarching conceptual framework, and summarizes and integrates the other 11 chapters. It will also detail the Friesen Conference, entitled *"Understanding and Fostering Resilience in Older Adults,"* held at Simon Fraser University, June 10–11, 2019, that served as a springboard for this work. This chapter also positions resilience thinking against broader theoretical developments in the gerontological literature, including positive and developmental psychological approaches of aging, the selection, optimization, and compensation (SOC) model, life-course theory, stress and homeostasis theory, person-environment theory, socio-environmental theory, complex systems models, community development approaches, and successful aging models. It is contended that conceptual, theoretical, and measurement developments as well as innovations embedded in this volume will generate a new phase in resilience research applied to aging and older adults. This volume is particularly relevant in the current and post-COVID-19 era, which has placed aging-related issues in the forefront.

Keywords Resilience · Aging · History · Theoretical framing · Methodological challenges

Background

We have transitioned into a new phase of population aging—one that is characterized by a period of the most rapid aging in the United States, Canada, and many other nations. This is due to declining fertility, coupled with the aging of the large baby boom cohorts and extended life expectancy. As more individuals reach the

A. V. Wister (✉)
Department of Gerontology, Simon Fraser University, Vancouver, BC, Canada
e-mail: wister@sfu.ca

T. D. Cosco
Department of Gerontology Research Centrre, Simon Fraser University, Vancouver, BC, Canada
e-mail: theorore_cosco@sfu.ca

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upper levels of the age structure, the likelihood of experiencing age-related challenges will rise, thereby placing additional burden on health and social support systems. The degree to which older adults bounce back from different types and combinations of adversity or deal with adversity better than expected is termed *resilience*. While research has been accumulating that identifies inherent abilities and external resources needed to adapt and navigate stress-inducing experiences among aging and older adults, significant gaps remain in understanding the unique elements and processes of resilience. Some of the key challenges that older people experience include mental and physical health problems, especially multimorbidity; family change, such as widowhood; socio-economic deprivation; social isolation and loneliness; ageism and discrimination; housing problems; and environmental disasters, to name a few.

The current COVID-19 pandemic has raised the profile of gerontology and alerted experts working in academic, government, community, and private sectors to a new set of challenges. The relevance of resilience and aging research, knowledge and its translation into practice has become heightened for a number of reasons. Older adults are at an increased risk of experiencing deleterious outcomes if they contract COVID-19, ranging from lasting health complications to mortality. They are also more challenged than most individuals and families with respect to adaptations to the physical distancing policy. These inequities in adversity are most pronounced for the most vulnerable older people in society, especially those living in long term care, assisted living, or congregate care environments. Most COVID-19 deaths have been among this group. Furthermore, even though the majority of older adults living in the community in private households are relatively healthy and active, the pandemic has produced greater levels of stress, social isolation, and barriers to meet day-to-day needs. Physical distancing has exacerbated many of the social issues that many older individuals face, covering a large spectrum of health care, economic, physiological, social, and psychological issues. The COVID-19 pandemic has revealed the inadequacies in our current system-level structures, thus alerting us to focal areas for response and reform. Extending our knowledge of the role of resilience and aging will help society to maximize health and wellness in the face of a range of changing adversities.

A series of 12 chapters in this edited volume address several overarching questions pertinent to resilience and aging. These include: how do we conceptualize, model, measure, and analyze resilience; why do some older individuals/families/communities adapt to adversity better than others; what are the modifiable behavioral protective/risk factors related to resilience; how can we foster resilience at the individual/community level; and which interventions and public health approaches show the most promise? Indeed, the chapters comprising this book present cutting-edge science at the conceptual, methodological, empirical, and practice levels applied to emerging resilience fields in gerontology. Thus, the proposed volume will expand our understanding of how resilience works at the individual, family, and community levels; identify vulnerable groups of older adults who often face several concurrent challenges; examine different forms of resilience and their measurement; and isolate risk and protective factors.

This work identifies and elucidates promising areas for future research, as well as developments and potential new frontiers in policy and practice linked to these areas. Supporting and enhancing resilience through technological, social, and/or community-level, and public health advances in geroscience (the intersection of basic aging biology, chronic disease, and health) will help those facing adversity to thrive by harnessing, stretching, and leveraging a wide array of potential resources from the individual to the societal level. The promotion of healthier older populations has far-reaching consequences for health care and social/community support systems, both in terms of public health, and the development and implementation of innovations in treatment and practice guidelines.

Nine of the 12 chapters comprising this volume were based on presentations that were delivered as part of the John K. Friesen Conference held at Simon Fraser University, June 10 & 11, 2019, entitled "Understanding and Fostering Resilience in Older Adults." The conference drew over 100 participants interested in the emerging field of resilience and aging. Ten national and international speakers delivered keynote lectures at the conference and contributed chapters to this volume.

Early Resilience Manifestations

While there is not a singular definition of resilience in the broad literature, there is agreement that it entails overcoming significant adversity in order to regain prior levels of health and well-being or cope better than others facing the same adversity. Ungar (2008:225) states that resilience is "both the capacity of individuals to *navigate* the psychological, social, cultural and physical resources that sustain their well-being, and their capacity individually and collectively to *negotiate* for these resources to be provided and experienced in culturally meaningful ways." Similarly, Windle (2011:152) describes resilience as effectively negotiating, adapting to, or managing significant sources of stress by applying resources within the individual, their life, and environment to 'bounce back.'

Initially, resilience was applied to children and adolescents to understand how and why some youths overcome early life mental health adversity as a component of developmental psychology (Masten 2001, 2007). Since its early applications, resilience has been used as a strength-based approach to understand recovery in other sub-populations, vulnerable groups, and from different types of adversity, including older adults facing a variety of challenges. Researchers have encapsulated resilience thinking into five overlapping phases or waves (Masten 2007; Wister et al. 2016). The first wave of research identified qualities, characteristics, and resources within individuals and families that are associated with resilience primarily in terms of psychological outcomes (Masten 2007; Richardson 2002). However, gaps remained in the knowledge-base with respect to processes and mechanisms underlying resource utilization to foster resilience, in particular, from a life-course lens (Leipold and Greve 2009; Ong et al. 2009; Windle 2012).

The second wave of resilience research addressed adaptive and coping processes (Masten 2007; Ong et al. 2009; Richardson 2002). Central to these developments is stress theory, in which adaptive and coping processes, especially buffering effects of social support, interact with risk factors. An important development during this phase was the integration of an ecosystem perspective that acknowledged the interdependence of social and environmental systems (Stokols 1992; Pearlin et al. 2005; Ungar 2011; Wild et al. 2013).

In the third wave, extension of prior research was connected to the development of interventions to strengthen resilience (Richardson 2002; Masten 2007). Yet, measurement and conceptual challenges limited these advancements (Cosco et al. 2017; Ungar 2011; Windle et al. 2011; Windle 2012). The fourth wave of resilience research focused on multi-level analyses across micro-, meso-, and macro-levels, as well as traversing disciplines (Masten 2007). Efforts were also made to link resilience factors and processes. Research largely utilized psychological measures such as self-efficacy, mastery, optimism, etc. to examine this area of inquiry.

A fifth phase of development has been identified in which the prior generalized, meta-models are specified to particular problems and contexts, including those located in the field of gerontology (Wister et al. 2016). Some recent examples in gerontology include: family resilience and aging (Martin et al. 2015); genetic and physical resilience (Peters et al. 2019); successful aging (Resnick et al. 2015; Windle 2012); cultural specific resilience (Ungar 2011; Wiles et al. 2012), resilience and mental health (Cosco et al. 2018), multimorbidity resilience (Wister et al. 2018, 2019), resilience and widowhood (Carr, Chapter "Psychological Resilience in the Face of Later-Life Bereavement"; King et al. 2019), and work, retirement and resilience (Coon 2012) (also see subsequent chapters).

Theoretical Framing of Resilience and Aging

Resilience has theoretical roots in a constellation of social-psychological, sociological, and socio-environmental concepts and models, addressing adaptation to individual and environmental adversity. While this list is expansive, some of these include positive and developmental psychological approaches, life-course theory, stress and homeostasis theory, person-environment theory, and socio-environmental theory. Resilience models also have developed due to the limitations of successful aging models (Harris 2008; Pruchno and Carr 2017) and gaps in explaining adaptation to adversity (Cosco et al. 2017, 2018; Wister et al. 2016).

Positive psychology adopts an individual-level lens, focusing on the pursuit of adaptive, creative, and emotionally fulfilling aspects of human behaviour (Seligman and Csikszentmihalyi 2000). The advancement of well-being is determined by the strengths and resources (i.e., individual resilience) of people to adapt to life challenges (Emlet et al. 2011; Seligman and Csikszentmihalyi 2000). It also encompasses the idea of salutogenesis, which aims to study the etiology of health,

especially health-fulfilling aspects linked to a resilience framework, and is antithetical to the pathology perspective (Antonovsky 1996; Emlet et al. 2011).

A number of developmental psychology theories are also foundational to resilience in their conceptualization of balancing gains and losses along the stages of life required for optimal development (Baltes and Carstenson 1996; Boerner and Jopp 2007; Leipold and Greve 2009; Pearlin et al. 2005). The classic stress-coping model contends that social support can intercede or buffer stress to reinstate balance (Pearlin et al.'s 1990). The model of assimilative and accommodative coping contends that coping is defined by two antagonistic processes. Assimilation is the persistent effort to pursue goals through modification of life circumstances, whereas accommodation entails adjustment of goals in the face of constraints (Boerner and Jopp 2007; Greve and Staudinger 2006; Hardy et al. 2004; Leipold and Greve 2009). In their study of positive adaptation and valuation of life, Jopp and Rott (2006) found evidence of assimilation and accommodation processes of resilience, whereby older adults were found to maintain their goal of social connectedness by replacing face-to-face interpersonal contact with telephone contact during functional decline.

The selection, optimization, and compensation (SOC) model of aging and development proposes a dynamic interlocking system of adaptation (Baltes and Carstenson 1996; Wild et al. 2013. Based on this theory, selection is the decision process of prioritizing, optimization is the activation of appropriate resources, and compensation is the application of alternate means to maintain function (Boerner and Jopp 2007). All three processes are integral to bouncing back from adversity, or responding better than expected to adversity, embedded in aging processes. For instance, positive adaptation (i.e., resilience) is enhanced when individuals align available resources and goals (Baltes and Carstenson 1996). In this regard, Wiles et al. (2012) found that the most resilient older adults tended to persist with activities that were important to them when challenged by multimorbidity.

Another cluster of theories push the boundaries of conceptualizing resilience beyond the individual. Life-course theory is a paradigm that has been at the centre of gerontology. It provides a bridge and a dynamic interplay between structural (i.e., historical, institutional, community, and cohort-related) and individual (i.e., social resources and agency) factors that influence health and social trajectories of individuals as they age (Dannefer et al. 2009; Elder and Johnson 2003; Mitchell 2003; Wister 2019). These same processes are applicable to resilience and aging theorizing. First, the life-course perspective purports that human development and aging are lifelong processes that are influenced by the timing and intensity of early life experiences, events, and transitions. These might entail childhood trauma or social conditions that may weaken resilience or provide experiential learning to strengthen resilience. Second, individuals proactively employ human agency to shape social structures (e.g., the effect of voting for health care reform) (Mitchell 2003). Third, historical events and the size of the age cohorts to which individuals belong influence experiences and trajectories. The role of the food industry on increasing obesity could, for example, exacerbate chronic illnesses, such as arthritis, while also eroding resilience by constraining physical activity level (Wister 2005). Fourth, life course emphasizes that lives are lived interdependently such that we affect and are

affected by our social networks. The presence of a partner in older age can provide a social safety net to overcome adversity. Finally, life-course resources or capital available to individuals (e.g., genetics, literacy, knowledge, wealth, health, social relations, identity, competence) and life-course risks (e.g., genetics, class, race, ethnic, age, or gender stratification) create opportunities (advantages) or adverse conditions (disadvantages) that influence how life stressors are experienced (O'Rand 2006). Rybarczyk et al. (2012) review several studies in which evidence is provided, demonstrating how accumulated life experiences can inoculate older persons to negative health conditions. Coupled with a developmental perspective, life-course axioms point to a 'resilience trajectory' applied to aging, wherein previous life experiences of coping and overcoming adversity may enrich one's ability to deal with the continued challenges of aging.

The above theories, however, do not fully explain how individual-level resilience is interconnected to multi-level environmental domains. Both complex systems models and socio-ecological approaches emphasize the interrelatedness and interdependency between individuals, social systems, and the environment (Linkov and Kott 2019; Linkov et al., Chapter "Science and Practice of Resilience: Disaster Systems Applications to Aging Model Development"; Stokols 1992). Complex systems models contend that understanding the effects of adversity on an individual requires a system-level analysis of risk and resilience. Similarly, the socio-ecological approach stresses balance between an individual's needs and abilities and the demands of the environment (Greve and Staudinger 2006; Lawton 1980; Lewin 1951). Applied to physical and social environments, Lawton (1980) refers to the correspondence between the abilities and characteristics of the individual (their competence) in relation to the demands and resources of the surrounding physical (e.g., housing) or social (e.g., family/friendship network) environment. All of these theories contend that a balance or homeostasis is necessary to enhance resilience trajectories. While there is an assumption that older people can withstand less environmental stress than more resilient younger persons, there are undoubtedly ways to optimize positive outcomes. In one application of this approach, Wild et al. (2013) offers a model of six nested domains to reflect contextual and collective dimensions of resilience for persons in later life. These include: individual resilience, household resilience, family resilience and neighbourhood resilience, community resilience, and, lastly, societal resilience. The idea of nested spheres of influence provides a useful conceptual framework to understand how resilience is the manifestation of a complex set of interrelated systems.

Finally, it is also useful to contrast resilience frameworks with successful aging (SA) models, given the historical prominence and formative role of the latter in gerontology. The SA model, which originally appeared in in the 1960s and further developed in the 1970s and beyond, attempted to explain why some older people age better than others (Rowe and Kahn 1997). This approach tended to broadly assess older people asfv aging well if they were a) free of disease; b) high in cognitive and physical functioning; and c) actively engaged in life (DiPietro et al. 2012; Rowe and Kahn 1987). This has led to criticisms that the model overly concentrates on a small proportion of individuals meeting these criteria (Rowe and Cosco 2016),

which has led to some revisions. An important distinguishing feature of the SA model and resilience frameworks is the incorporation of adversity into conceptualizations of resilience, which brings sharper focus to a broader population of older adults, and more specifically, how adversity is experienced over the life course. Resilience models, therefore, extend the SA model by bringing attention to strength-based approaches to understanding positive and negative trajectories of aging (Pruchno and Carr 2017). Several fundamental axioms of resilience and aging can be drawn from this work, and serves as a platform for the chapters comprising this volume. (1) Resilience is a protective, adaptive, or coping response to aging-related adversity. (2) Adversity ranges in terms of type, severity, fluidity, and duration. (3) The underlying mechanisms and processes of resilience are connected to the life course of individuals and are central to impacts on key outcomes. (4) Resources are embedded in the individual, family, community, and broader socio-political environments. (5) Accessibility and availability of resources that can be harnessed shape resilience. (6) Resilience is experienced at multiple levels—including physiological and psychological disruptions to well-being, social manifestations, as well as those occurring at a community or system level. (7) There are both generic components of resilience common across types of adversity, populations, and time-periods, and specific ones related to unique dimensions or diversity of groups.

Methodological Challenges in Resilience Research

The operationalization of resilience stemming from theoretical developments along the five phases of development has been slower to materialize for researchers, in part, due to the challenges in a multifaceted conceptualization of resilience. Issues of scale and index development and testing, statistical approach to analyze responses to adversity (e.g., data driven, a priori approaches, moderation analysis, regression from mean of least squares) fold another layer of complexity to resilience research. Innovation in techniques, coupled with new data that can capture change, offer exciting challenges to this area of inquiry.

Contents of this Edited Volume

This book attempts to add to these developments in the resilience and aging literature in order to aggregate what is known in this emerging field. The 12 chapters aim to: (1) identify gaps and conundrums in what we know; (2) integrate and add coherence to the often siloed knowledge that has accumulated to date; (3) apply resilience and aging lens to current and emerging topics in gerontology; (4) carve new paths for innovative research; and (5) identify intervention, policies, and practical approaches that offer the most promise, as we move into the next developmental phase of resilience and aging.

The second chapter, entitled "Resilience in Older Adults: What It Is and How to Strengthen It," written by Barbara Resnick, provides a deeper conceptualization of the concept of resilience with the purpose of uncovering some of the underlying processes embedded within this concept. Drawing on Richardson's (2002) model of resilience qualities and traits, ranging from spirituality to social relationships, this chapter helps to unravel the multilayers of resilience and to direct researchers to potential areas for new science. These advancements lead to pockets for intervention developments that show promise in strengthening resilience in older adults. The third chapter, entitled "Resilience in Later Life: Responding to Criticisms and Applying New Knowledge to the Experience of Dementia," authored by Gill Windle, further extends the above work in several ways. She elucidates how the concept of resilience applied to later life has proliferated in research, policy, and practice. The chapter also shows the ways that resilience research challenges aging stereotypes, ageism, and discrimination. In opposition to many early and even current studies of aging, this work, in parallel with the other chapters in this volume, considers the often-neglected area of positive adaptation. Yet, she acknowledges the criticisms and challenges that we face, especially when we attempt to use resilience research to direct public health policy for aging populations. These issues are brought to the foreground by applying a resilience framework to dementia in an effort to identify both pitfalls and pathways for researchers applying this approach.

In the fourth chapter, "Science and Practice of Resilience: Disaster Systems Applications to Aging Model Development," Igor Linkov and associates aim to apply a complex systems model developed by the National Academies of Science to study natural disasters, including COVID-19 and other pandemics, to the field of resilience and aging. The authors weave together relevant literature in gerontology, medicine, and public health, in order to develop a new generalized framework for quantifying resilience for elderly individuals. This chapter points us to the importance of understanding resilience, and the mechanisms underlying it, as part of a multi-level integrated system that influences age-related adversity and the access to resources to recover. Linkov and associates detail how a complex systems model of resilience can be used to organize and reorganize health care, improve quality of life, and decrease the burden of care.

The fifth chapter, written by Andrew V. Wister, is entitled "Multimorbidity Resilience: Conceptual, Theoretical and Measurement Developments" and is separated into two parts. The first provides a rationale and describes the development of a theoretical model of multimorbidity resilience; the second details a new multimorbidity resilience index for use in population health surveys. Consistent with the fifth wave of resilience developments, Wister focuses specifically on multimorbidity as a major form of adversity facing older adults, which has become particularly relevant during the COVID-19 pandemic. The Lifecourse Model of Multimorbidity Resilience connects multi-level domains of influence that shape resilience outcomes, and identifies processes that affect illness disruption and reintegration of individuals by means of resilience mechanisms. The outcomes of wellness, recovery, and growth/development are connected to harnessing resources at the micro and macro levels in order to overcome the deleterious influence of multimorbidity.

A multimorbidity resilience index comprising functional, social, and psychological domains, capturing both adversity and adaptation, is described in the second section of the chapter. The criterion validation of the index, using the Canadian Longitudinal Study on Aging based on health care utilization and health status outcomes, is presented and offers support for this measure.

In the sixth chapter, entitled "Quantitative Approaches to Examine Resilience and Aging," Almar Kok and colleagues address methodological issues in this field. The authors categorize major methodological approaches specifically applied in resilience research. These entail, for instance, estimating "buffering" effects of hypothesized protective factors in the effect modification, scale construction, comparison of resilience characteristics between predefined groups, data-driven subgroup identification in the latent class analyses, assessing predictors of adversity-outcome residual values in regression analyses, and stressor-response patterns in high-density time-series, based on a systems approach. Kok and colleagues review the strengths and limitations of each method and provide examples located in the research literature.

In the seventh chapter, entitled "Positive Affect as Source of Resilience in Adulthood and Later Life," written by Anthony Ong, a developmental program of research on resilience and aging is presented. The authors selectively review the growing resilience literature, focusing on primary approaches, research findings, and guiding principles that characterize these studies. The chapter concentrates on psychological affect as a basic building block of resilience in adulthood and later life. They articulate how some individuals recover and/or maintain health and well-being due to a dynamic conception of positive affect as a central component of resilience. Ong and colleagues point us to future research directions to advance understanding of adulthood resilience.

Deborah Carr offers the eighth chapter, entitled "Psychological Resilience in the Face of Later-Life Bereavement." The author eloquently articulates developments in stress and coping models and applies these to psychological resilience following late-life spousal loss. Contextual, relational, and personal characteristics associated with widowhood are connected to the stress-coping nexus to help us understand how psychological well-being can be compromised, as well as how coping resources can facilitate resilience. Carr moves the discussion beyond the individual in order to elaborate the layers of both social/structural and developmental factors that are linked to resilience among older bereaved spouses. She reviews, synthesizes, and puts into a resilience framework widowhood literature related to age patterns, relationship quality prior to spousal loss, social support, and spousal death contexts. The primary factors that distinguish those who withstand or bounce back emotionally to widowhood in later life, compared to those who do not are reviewed. In this chapter, Carr identifies potentially modifiable aspects of these factors for two purposes. First, she challenges notions that resilience is a trait-like feature of the individual alone. Second, she uses this discussion to direct future research efforts that can advance our understanding of resilience, stress, and coping among older widowed individuals, as well as potential practice/policy initiatives to foster resilience.

In the ninth chapter, entitled "Physical Resilience: Motor Function and Aging," Sue Peters brings attention to one specific resilience domain—physical resilience. Defined as the ability to optimize/recover function in response to disease, injury, or age-related physical decline, physical resilience is examined as a fundamental component of aging. Peters attempts to answer two key questions: (1) What differentiates those who improve or bounce back from those who do not? (2) Can mobility rehabilitation be improved with knowledge of physical resilience? She elaborates on research literature in which this domain has developed, but also elaborates on its interconnections with other domains. Indeed, physical resilience is inherently multifaceted and linked with biological, sociological, and psychological factors. The chapter provides detailed discussion of physical resilience in relation to rehabilitation of older adults with various pathologies that limit function.

In the tenth chapter, entitled "Mobility Resilience Processes Among Older Adults," Kishore Seetharaman and coauthors extend the prior chapter in its focus on mobility resilience. Drawing on resilience frameworks with processes of adaptation articulated in the Selective Optimization and Compensation (SOC) model, the authors investigate mobility challenges among older adults, termed mobility resilience. This integrative summary uses 41 primary studies found in the literature to identify the range of adaptive processes employed by older adults with mobility limitations. Classes of reintegration in the resilience model are identified and elaborated based on the adaptive processes found to be most relevant in the literature. This review provides important insight into: (i) why some older adults adapt to or recover from mobility limitations better than others; and (ii) the factors and processes involved in fostering mobility resilience. This work helps to develop innovative programs to enhance older adults' health and well-being.

Sarah Canham applies resilience concepts to the burgeoning field of homelessness in the eleventh chapter, entitled "Advancing the Concept of Resilience for Older Adults Who Are Experiencing Homelessness." In concert with prior chapters, the author identifies the lack of congruence of resilience conceptualizations, especially applications to vulnerable populations. Canham provides arguments that the lived experiences of homeless older adults are fundamental to understanding pathways to 'bounce back' and return to states of physical and psychological homeostasis at the latter stages of the life course. Drawing on results from a recent community-engaged research project that examined trajectories of homelessness after hospital discharge, this chapter provides applied research foci on cumulative adaptive capability across different temporal locations. A model of resilience among homeless older adults framed by an ecological perspective is developed and juxtaposed with earlier resilience models. The chapter concludes by providing the reader with a discussion of future research, policy, and practice.

The twelfth chapter, written by Janine Wiles, is entitled "Communities and Resilience: Contextual and Collective Resilience." In parallel with several prior chapters, the author shifts resilience thinking beyond the individual to the community and broader environment. In addition, Wiles positions resilience as a collective, contextual, and participatory process and outcome. From an ecological perspective, Wiles elucidates micro, meso, and macro domains of influence, in which resilience

is negotiated. Of particular importance is the distribution of adversity and inequality affecting older people and of access to resources for resilience. The author develops the idea of collective resilience, which necessitates recognition of the ways in which thoughtful collaboration can be fostered, especially when our focus is with vulnerable and diverse older people. For instance, Wiles discusses how strong partnerships across sectors can be fruitful in strengthening community resilience.

Summary

The field of resilience and aging is one of the most rapidly expanding areas in gerontology. Building upon foundations laid in developmental psychology by notable researchers as Michael Rutter, Michael Ungar, Ann Masten, among others, resilience research has expanded its scope across the life course into research on older adults. As models of aging that do not incorporate adversity began to fall out of favour, for example, Rowe & Kahn's classic tripartite "successful aging" model, a new wave of resilience research was ushered in and expanded upon. Researchers in a variety of disciplines and substantive areas are applying resilience concepts, theories, and measures to gain a deeper understanding of how individuals, families, communities, and societies respond to different types of adversity. Resilience models are not bound by disciplinary paradigms and are able to transcend perspectives, ranging from physiological responses to psychological adversities to psychological responses to physiological adversities. Similar to the interdisciplinary nature of the field of gerontology, resilience research is able to provide a multifaceted lens to the complexities of aging and age-related adversities that accompany this process. Together, the chapters comprising this volume offer new knowledge, evidence, policy, and practice in the emerging field of resilience and aging. The collective expertise of the contributors is not only expansive but also diverse in interdisciplinarity, reflecting comprehensive multi-level developments in this field of study. Given that we are in the formative phases of knowledge development in resilience, the reader is provided with both gaps and potential new science opportunities.

The greatest remaining schisms include consensus and consistency in conceptual definitions of resilience; advancements in both generalized and specified theories of resilience; development and testing of measures; innovation in designs best suited to understand resilience mechanisms, as well as structural associations; new and replicated studies in relevant sub-fields; and development and evaluation of programs and policies aimed at improving resilience among aging and older adults. As the field grows, we hope that these research and knowledge gaps will be filled, and the translation of this work will lead to a healthier population. *Resilience and Aging: Emerging Science and Future Possibilities* offers a springboard for this important work ahead.

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Resilience in Older Adults: What It Is and How to Strengthen It

Barbara Resnick

Abstract This chapter provides a comprehensive discussion on the concept of resilience and identifies underlying processes and areas for new discovery. It begins with its formative developments in psychology and transitions into application to the field of aging. This work is framed by an overarching resilience model based on Richardson (J Clin Psychol 58(3):307–321, 2002). A set of key resilience qualities and traits, and their underlying processes, are detailed and discussed based on research, ranging from spirituality to social relationships. These lead to a number of intervention strategies that show promise in strengthening resilience in older adults.

Keywords Resilience · Older Adults · Knowledge · Developments · Models Interventions

Definition of Resilience

The word 'resilience' originates from the Latin word 'salire,' which means to spring up and the word 'resilire,' which means to spring back. Resilience is therefore broadly defined as the ability to spring forward or recover from a crisis or a challenge that might be physical, physiological, emotional, financial, role related, or socially related. Alternatively, resilience has been described as the ability to overcome the odds, or make markedly successful adaptations (Fraser et al. 1999). Regardless of some variation in definition, the ultimate goal in resilience is to not only spring back to where you were before the crisis, but to spring forward and grow from the experience. The American Psychological Association defines resilience as "the process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress" (American Psychological Association Help Center 2004). Being resilient indicates that the individual has the human ability to adapt in the face of tragedy, trauma, adversity, hardship, and ongoing significant life

B. Resnick (*)
School of Nursing, University of Maryland, College Park, MD, USA
e-mail: resnick@umaryland.edu

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stressors (Newman 2005). Resilient individuals demonstrate adaptive behaviors especially with regard to psychosocial factors and experiences, and are less likely to succumb to illness or disability (Battalio et al. 2017; Bolton and Osborne 2016; Byun and Jung 2016; Manning et al. 2016). Similarly, the Healthy Aging Network defined resilience as the process of negotiating, managing, and adapting to significant sources of stress or trauma. Assets and resources within the individual, their life, and environment facilitate this capacity for adaptation and "bouncing back" in the face of adversity. Across the life course, the experience of resilience will vary (The Aging Network 2019). Resilience is more than fighting off an acute or challenging situation and regaining homeostasis. Resilience requires that the individual recover from the acute challenge and grow through the experience.

Figure 1 provides a model of resilience referred to as the Resilience Model (Richardson 2002) (Fig. 1). This model indicates that when an individual is challenged by some type of experience or illness, such as a fall, a hip fracture, a cancer diagnosis, renal failure, the loss of spouse, a pet, or employment, the individual has the choice to use internal protective factors, such as self-reliance, self-efficacy, and

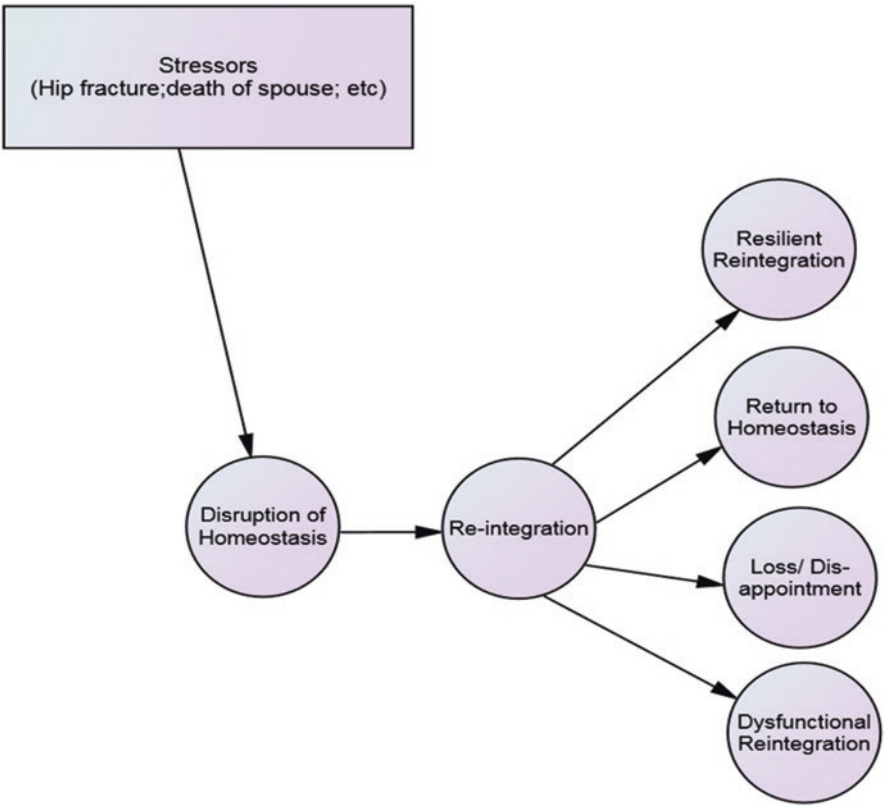

Fig. 1 A model of resilience

self-esteem, as well as psychological and physical health, and external protective factors, such as social networks to restore balance to life and grow through the experience. There may also be physiological factors that help to facilitate a resilient response to a challenge, such as those noted in the flight or fight response. When an individual engages in resilient behavior and grows from the challenging experience encountered, this is referred to as resilient reintegration (Richardson 2002). In the case of resilient reintegration, the individual does not simply regain homeostasis, but he or she grows physically, physiologically, or emotionally. Alternatively, the individual can choose to return to homeostasis. Homeostasis is the maintenance of a physiological or psychological state within certain set limits. Homeostasis implies that the system remains stable. Many older individuals, for example, following a hip fracture, will set as a goal to maintain homeostasis and return to their prior functioning. For this type of resilience to occur, the goal would be for resilient reintegration and they would not only resume their prior function but increase time spent in physical activity to improve balance and strength, and thereby prevent future falls.

Another alternative response to a challenging experience for older individuals is to not regain homeostasis. Using the example of the older individual who experiences a hip fracture, someone who is less resilient may go to physical therapy, but not practice what is learned or engage in any physical activity out of therapy and thus will not regain baseline function. This individual may experience a sense of loss and disappointment as he or she may no longer be able to bathe and dress independently or ambulate without an assistive device. Lastly, the older individual can respond to a stressor by becoming dysfunctional and unable to cope. In this scenario, the individual who experiences a hip fracture may refuse to participate in any therapy, get transferred to long term care and become increasingly dependent, depressed, and deconditioned (see Fig. 1).

The Conceptualization of Resilience as a Trait, Process, and/or Outcome

Resilience has been conceptualized as a personality trait, a process, and/or as an outcome (American Psychological Association Help Center 2004). Although resilience is a component of the individual's personality, it develops and changes over time through ongoing experiences with the physical and social environment (Hegney et al. 2007; Lee et al. 2008). Resilience should be perceived as a dynamic process that is influenced by life events, opportunities, and challenges that can develop or deteriorate over time (Grothberg 2003; Hardy et al. 2004; Wister et al. 2016). There may be changes in resilience as people change over the life span. Children may develop resilience through exposure to strong mentors or role models. As they become adults, they may be exposed to physical, social, emotional, or economic challenges and not adapt well. Subsequent interventions may promote their inherent capacity to bounce back. Some consider resilience, or evidence of resilience, to be

based on one or two factors that are associated with resilience such as having "grit" or determination or being optimistic (Bolton et al. 2016). While these are characteristics of resilient individuals, they are not the equivalent of resilience. Conversely, resilience has also been assumed based on evidence of improvement or some type of positive clinical outcome (e.g., better function, less depression). While these outcomes may be due to the resilience of the individual, they are not equivalent concepts. For example, improvement in function post hip fracture may occur in some individuals due to resilience and determination to recover. Others may show improvement due to the natural trajectory of bone healing and functional recovery.

Different Types of Resilience

Although often considered a generic personality component, there are many areas in which individuals are resilient. Most commonly, resilience has been differentiated into health resilience (Sanders et al. 2008), psychological resilience (Boardman et al. 2008), emotional resilience (Chow et al. 2007), dispositional resilience (Rossi et al. 2007), physical resilience (Resnick et al. 2011; Whitson et al. 2016), and physiological resilience (Klinedinst and Hackney 2018; LeBrasseur 2017; Ukraintseva et al. 2016) or biological resilience (De Alfieri et al. 2017). All of these different types of resilience reflect being able to maintain a positive attitude and endure through any variety of health-related, emotional, or social challenges. Moreover, it is anticipated that resilience translates across areas of physical and mental health so that those who are physically resilient are more likely to be resilient to psychosocial challenges and vice-versa.

Psychological resilience is focused on being able to maintain a positive affect when exposed to psychological stresses, such as the loss of a spouse, friend, or pet. Psychological or emotional resilience refers to an individual's capacity to withstand stressors and not manifest psychological dysfunction, such as mental illness or persistent negative mood. Psychological stressors for older adults commonly include such things as the death of a loved one, chronic illness, verbal or physical or emotional abuse, or fear due to living situation, a fear of falling, or a fear of dying. Individuals who have emotional or psychological resilience are able to "roll with the punches" and adapt to challenges and adversity without a negative impact and grow through the experience. There is a physiological aspect to emotional resilience, supporting the evidence that resilience is in part personality and in part experience. Low emotional resilience has been associated with increased or overactive amygdala function (Leaver et al. 2018). Overall, there is evidence that emotional resilience increases with age and older adults have decreased attentional bias to negative stimuli compared to younger individuals (Ukraintseva et al. 2016). Amygdala nuclei and related brain circuits have been linked to maintaining negative affect and depression. Those individuals who are depressed, for example, have

abnormal amygdala function. Individuals who were not depressed were noted to have higher connectivity between the amygdalae and dorsal frontal networks. Thus, there is direct evidence that an association exists between resilience and amygdala networks (Leaver et al. 2018).

Dispositional resilience incorporates three personality characteristics, including commitment to others, a sense of control over outcomes, and a willingness to learn from the current situation. These three qualities are evident when someone has dispositional resilience. People who have dispositional resilience make social connections, avoid seeing crises as insurmountable, accept change as part of living, move towards set goals, take decisive action, look for opportunities for self-discovery, nurture positive views, keep things in perspective, maintain hopeful outlooks, and work on self-care related activities (Rossi et al. 2007).

Health resilience is the capacity to maintain good or optimal health in the face of significant adversity or to recover from illness (Cosco et al. 2017; Sanders et al. 2008). Evidence of health resilience is the ability to maintain good health in the face of challenges, with good health including both physical and mental health. The specific health challenge encountered by an individual might be physical, psychological, emotional, or social. For example, those without health insurance and less access to health care resources would be challenged to maintain health if they had to pay for health promoting activities (e.g., immunizations) out of pocket. Likewise, it might be challenging to maintain good psychological health without any social supports, such as what can occur in older age when one has outlived family and friends. Further, in disease states, such as dementia, where there is no ability to "recover" to full cognitive health, accepting the disease and optimizing cognitive function and ability would be indicative of health resilience.

Physical resilience is the ability to recover or optimize function in the face of age-related losses or disease. It is the body's ability to adapt once challenged, and recover whether it be related to acute damage, deconditioning, or nutritional deficits, treatment-related challenges or changes in the function of systems. Physical resilience relates to the ability to recover or optimize function in the face of age-related losses or disease (Resnick et al. 2011). Physical resilience is a central aspect of successful aging and recovering from acute events, such as a hip fracture, pneumonia, and the flu. Physical resilience is impacted by many factors, including psychological status of the individual, social support, genetics, physiological reserve, life expectations, and the environment (Whitson et al. 2016).

Physiologic or biological resilience is the capacity of an organism to resist and respond to a physiologic stressor or challenge (De Alfieri et al. 2017). Physiologic resilience is associated with the individual's flexibility in his or her neurochemical stress response system and neural circuitry involved in stress responses. Prior research has shown that being exposed to stress, whether this is chronic or acute stress, can result in depression, anxiety, or other types of negative psychological and physical outcomes (Taliaz et al. 2011). Stress, and the stress-response system, can cause alterations in brain structures associated with cognition, mood, and behavior

within the hypothalamic pituitary-adrenocortical (HPA) axis. In addition, the response to stress impacts neurotransmitters, neuropeptides, and hormones and some individuals respond with resilience, while others decompensate when exposed to the same type and level of stress. The systems believed to be involved with facilitating physiological resilience include those that regulate glucose tolerance, the hypothalamic pituitary adrenal axis, the autonomic nervous system, the inflammatory response system, and catecholamine production (Varadhan et al. 2018).

Serotonin has been the most commonly studied neurotransmitter and the serotonin gene, solute carrier family 6 neurotransmitter transporter (*SLC6A4)* is the gene most commonly associated with resilience, at least among older adults (Feder et al. 2009; O'Hara et al. 2012; Resnick et al. 2015). Some additional genes that are believed to be involved with prefrontal cortex reactivity associated with fear and other stressors have also been associated with resilience. These genes include brain-derived neurotrophic factor (*BDNF),* corticotropin-releasing hormone receptor 1 (*CRHR1),* peptidyl-prolyl cis-trans isomerase FKBP5 (*FKBP5),* glutamate receptor metabotropic 1 (*GRM1*), solute carrier family 6 member 15 *(SLC6A15)* and catechol-O-methyltransferase (*COMT).*

Some additional genes have been associated with response to stress and subsequent depression in animal models and/or humans and consequently are anticipated to be associated with resilience. These genes include neuropeptide Y (*NYP*), neurotrophic tyrosine receptor kinase-1 and 2 (*NTRK-1; NTRK-2*) and guanine nucleotide binding protein beta polypeptide 3 (*GNB3*) (Taliaz et al. 2011). Overall, the genetic aspects of resilience provide support for the personality component of this characteristic.

Individual Factors Associated with Resilience

Many factors or qualities within individuals have been associated with resilience in general (Table 1). These include such things as positive interpersonal relationships, building social connectedness with a willingness to work with others, strong internal resources, having an optimistic or positive perspective about life and challenges encountered throughout the lifespan, maintaining realistic expectations, setting achievable goals and working towards those goals consistently, high self-esteem, high self-efficacy, determination, spirituality, which includes a sense of purpose of life, maintaining a sense of community and a belief in a higher power, being creative and having the ability to use humor and maintain a sense of curiosity, among others (Bolton et al. 2016; Bonanno et al. 2007; Charney 2004; Laird et al. 2019; Lamond et al. 2008; Ong et al. 2006). Some of these qualities may be traits of the individual and others are learned behaviors and responses that develop over time and through the course of an older adult's life.

Table 1 Resilient qualities or traits commonly noted in older adults

Positive interpersonal relationships
Strong self-efficacy
Positive self-esteem
A sense of purpose
Spirituality
Ability to use humor
Creativity
Acceptance of changes (physical and mental)
Maintaining a positive attitude
Ability to identify and utilize resources
Self-determination
Optimism
Seeing joy in each day
Grit
Maintaining hope
Adaptive coping styles
Meaningfulness
Prior experiences with hardship
Self-acceptance
Keeping things in perspective
Taking care of oneself—physical and emotional care
Avoid seeing crises as insurmountable
Setting goals and working towards them
Extending oneself to others (helping others)
Accepting vulnerability
Being independent and self-reliant
Access to resources—Social and material

Positive Interpersonal Relationships

Interpersonal relationships include interactions with family, friends, colleagues, and other acquaintances that the individual may interact with for physical, social, or psychological purposes. With regard to health resilience, relevant interpersonal relationships include interactions with health care providers encountered through any variety of health care situations. Interpersonal interactions and activities, whether receiving help from others or providing support or help of some kind to others, serves as a psychological buffer against physical and emotional stress, anxiety, or

depression. Interpersonal activities also help individuals cope with losses. When one individual is helping another individual with physical tasks, specific services (e.g., providing a ride to an appointment) or providing social support and friendship, it generally results in a sense of belonging and purpose, and strengthens self-esteem and self-efficacy. Thus individuals, who volunteer to do such things as work with children in reading programs, deliver the mail in continuing care retirement communities, or serve on committees or boards, tend to be more resilient than those who are not willing to engage with others in this manner. For older adults, community-based living in senior housing, assisted living facilities, or long-term care facilities may help improve or increase opportunities for interpersonal relationships, and thereby strengthen resilience.

Strong Internal Resources: Self-efficacy, Self-esteem, Determination, Problem Solving

Self-efficacy is the belief in one's ability to organize and execute a course of action to achieve a specific outcome (Bandura 1997) and as such impacts one's resilience. Different than self-efficacy, self-esteem is reflective of one's appraisal of his or her self-worth. Individuals, who have a positive sense of self-worth, accept and like themselves, and refrain from being "too hard on themselves" are more likely to be resilient and maintain their psychological health. There are numerous interventions to strengthen self-esteem, such as thinking positively about one's self, taking care of yourself, decreasing stress, doing things that you enjoy, being creative, setting realistic goals, and being kind and helping others (Burton 2019).

Determination or hardiness, also referred to as 'grit', is another important component of resilience. There are just some individuals who are determined and this is noted to be a central aspect of their personality. Determined individuals tend to be more confident in their ability to cope with health challenges, such as the diagnosis of a malignancy, or the ability to access resources to maintain health. These individuals are also more likely to seek out and find necessary resources to achieve their health-related goals.

Optimism, Positivism, and Keeping Things in Perspective

Optimism is one of the most commonly considered component or personality trait associated with resilience. Optimism has even been used as a proxy measure of psychological resilience (Ronaldson et al. 2015). Repeatedly it has been noted that having the ability to stay focused on positive outcomes in the face of challenges and avoid focusing on negative facts is critical to resilience. As with resilience overall, optimism is learned throughout life based on experiences and interactions with

others. At any point in time, optimism can serve as a buffer to becoming psychologically or physically unhealthy (Chung et al. 2016). Interestingly, optimism does not need to be rooted in truth to positively impact resilience and optimal coping. That is, unrealistic optimism may serve as an important buffer that can help individuals remain resilient in the face of challenges that might otherwise result in negative outcomes, such as subsequent worsening of health, depression, or anxiety.

Spirituality

Spirituality, considered broadly, includes a sense of self and purpose, creativity, humor, and a curiosity and willingness to learn and experience new things. Spirituality is not the same as religion. Rather it is a process of personal transformation, in accordance with traditional religious beliefs or based on subjective experiences and psychological growth independent of any specific religious context. Spirituality is a resource that is used to support the individual through challenges and can optimize and influence resilience in the face of a health challenge, such as the diagnosis of a malignancy.

Interventions to Strengthen Resilience

Although some individuals may be more likely than others to be genetically predetermined to be resilient (Feder et al. 2009) and have the personality traits that facilitate resilience, interventions can be implemented to strengthen resilience among all individuals. Examples of established approaches to helping individuals who are experiencing health challenges become more resilient are shown in Table 2. These interventions generally address four areas: (1) developing disposition attributes of the individual such as vigor, optimism, and physical robustness; (2) improving socialization practices; (3) strengthening self-efficacy, self-esteem, and motivation through interpersonal interactions as well as experiences; and (4) creative engagement. Technology and general lifestyle interventions are used to facilitate these interventions.

Developing Attributes of Resilience

Developing positive attributes, such as vigor, optimism, and a sense of physical robustness can be accomplished by using a variety of techniques. Humor, for example, may be helpful in accepting changes in function and ability and can help turn negative thoughts into more positive acceptance. Laughing about the physical changes that normally occur in aging, for example, changes in the muscular skeleton

Table 2 General intervention strategies to strengthen resilience

Acknowledge loss and vulnerability as experienced by the individual
Identify the patient's source of stress
Attempt to help stabilize or normalize the situation
Help the patient take control
Provide resources for change
Promote self-efficacy
Collaborate with the patient to encourage self-change
Strengthen the patient's problem-solving abilities
Address and encourage positive emotions
Listen to the patient's stories and encourage past review of recovery from stressors
Help the patient make meaning of the adverse or challenging event
Help the patient find the benefit to the adverse or challenging event
Assist the patient in transcending the immediate situation and giving it purpose

system, is a useful approach to adjusting to these changes rather than becoming depressed or responding to such changes negatively by no longer being willing to go out in public. Some individuals respond better to the use of humor than others and some are more sensitive to whether or not this is helpful as a form of resilience. Trying to keep challenges from becoming insurmountable and unresolvable problems can also help keep the challenge in perspective and maintain optimism. Likewise, reviewing prior and current strengths and trying to see oneself in a positive light can help build optimism. Encouraging hope, whether or not that hope is realistic in nature, can also build an optimistic attitude. For example, setting a goal of returning to home following a hip fracture may be an important aspiration for an individual to have, even if there are reasons that a return home may not be certain. Likewise, believing one will walk following an acute neurological event may also be extremely useful in terms of helping the individual be resilient and continue to engage in what may be difficult therapy sessions. Motivational interventions such as ongoing verbal encouragement and positive reinforcement and developing realistic and achievable goals related to the challenge being encountered can also help to build a sense of success, robustness, and ability to recover.

Improving Socialization Practices

Throughout life, there are losses that occur within one's social network, including losses among family members, friends, and colleagues. Maintaining and assuring

adequate social resources, however, is critical to building resilience (Sells et al. 2009). Therefore, helping individuals reach out and make connections with others, foster, and develop relationships can be an extremely effective way to strengthen resilience. Specifically, offering concrete ways in which to engage socially provides a framework for individuals to initiate social activities. Examples might include such things as making lunch or dinner dates, setting up bridge games, starting walking groups, attending exercise classes, or participating in volunteer activities. All of these activities can help build relationships that can grow into social supports. One particularly important skill to help older adults develop, following a challenging event, is to reach out and ask others for help. This also should be encouraged as an important development in building socialization practices.

Technology can be used to increase social support via emailing with friends and families or joining support groups online. Participating in self-help communities online can help build confidence and provide the critically important social support to continue to adhere to health behaviors or help adjust to new diagnoses. Further, social interactions via the internet can help prevent loneliness and depression in times of crisis and alleviate stress-related diseases.

Technology is also used to help with behavior change and facilitate some of the healthy behaviors that are needed to build self-esteem and influence resilience. Further, technology can help optimize safety and/or build independence for individuals living at home or helping them remain in the least restrictive level of care.

Strengthening Self-efficacy and Self-esteem

Self-efficacy is generally behavior-specific and is strengthened using four sources of information, including: (1) successful performance of an activity; (2) verbal encouragement to perform an activity; (3) seeing similar others perform; and (4) elimination of unpleasant sensations associated with an activity and strengthening or highlighting the pleasant experiences that result from the same activity (Bandura 1997). Generalized self-efficacy has been noted to be more comprehensive and more likely to be associated with an individuals' beliefs about personal abilities in general. General self-efficacy is defined as an individual's belief in their capability to manage or perform tasks across a wide variety of situations and is associated with self-esteem.

One of the best ways to strengthen self-esteem is to help individuals feel successful in their ability to complete a task. Facilitating success can be done by breaking a task down to small achievable goals, providing consistent positive reinforcement toward task completion, and showing the individual how others similar to him or her have successfully completed the task and being sure that the positive rewards and sensations associated with the activity are appreciated by the individual. Other

interventions that have been shown to be effective in strengthening self-esteem include such things as engaging in structured life reviews and participating in creative activities such as journaling, painting, or other types of creative endeavors. Self-esteem can be strengthened by eliminating negative self-talk, recognizing one's self-worth, and accepting mistakes and rejection. Lastly, lifestyle interventions can strengthen self-esteem, and thereby help build resilience. Lifestyle interventions include such things as nutrition, exercise, complementary and alternative medicine approaches, and meditation (Araújo dos Reis and de Oliva Menezes 2017; Cosco et al. 2017; Wermelinger et al. 2018). Nutritional intake can certainly influence health by decreasing the risk of heart disease and inflammation. Diets high in fruit and vegetables and those that focus overall on caloric restriction, while maintaining nutritional balance, are important to maintaining optimal health and possibly extending life. Along with nutrition, exercise has clearly been associated with maintaining a sense of overall health and well-being and can, therefore, facilitate resilience. Exercise has the benefit of improving both physical and psychological health and helping to prevent diseases, such as cardiovascular illness and psychological problems, particularly depression.

The use of complementary and alternative medicine for some is useful to optimize mood and strengthen one's resilience to interpret health status as good regardless of underlying disease. Interventions include such things as use of vitamins and supplements (e.g., omega-3 fatty acids; ginseng), acupuncture, yoga, meditation, and pastoral care or other types of spiritual interventions.

Creative Engagement

Exploring creative endeavors is particularly helpful for individuals during times of crises. Creative interventions have been shown to positively affect mental and physiological health (Laird et al. 2019; Majeski and Stover 2019). This might include taking art classes, dance and movement classes, and trying new activities such as learning to play an instrument or speak a foreign language. It is not unusual, however, for individuals to perceive themselves as not being creative and thus reluctant to engage in such activities. Innovative ways to encourage creativity, particularly for older adults, include encouraging individuals to initiate journaling or having them write life reviews or share their life stories verbally.

Group-Based Interventions to Strengthen Resilience

Several group-based interventions have been developed and tested to strengthen resilience following events, such as a stroke or co-morbidities associated with aging. The Community Wellbeing and Resilience Program (Bartholomaeus et al. 2019) was an 8-week multi-component program that included a focus on well-being and

resilience and had an optional mentoring/peer support opportunity. There was evidence of improved well-being, optimism, and resilience at the end of the program. Another tested group-based program to build resilience was the Back on Track program (Sadler et al. 2017) that was for individuals post stroke. This was a 6-week program that included sharing experiences, addressing ways to cope with losses, finding resources, social support, and provided opportunities to help others. Pilot testing with 11 individuals noted that this intervention was feasible and positively regarded by the participants.

Another group-based program was the 9-week Resilient Aging Program (Fullen and Gorby 2016). This was participant-centered and focused on strengthening the individual's self-concept or perception. The sessions provided information about resilience, provided examples of resilience and the impact of resilience on self-concept, addressed social wellness, psychological wellness, physical wellness, and spiritual wellness. Participants in these programs ranged from 59 to 95 years of age and were mostly African American with multi-morbidities. At the end of the program there was an increase in resilience, self-efficacy, and overall wellness.

Storytelling was another small group intervention used to strengthen resilience among older adults (Mager 2019). The Storytelling program was tested with a small group of eight participants. The intervention was implemented over a 5-week period and the weekly sessions included such things as telling a story about overcoming adversity, talking about an important relationship, a transition in your life that had an impact, and a story about how a health issue affected your confidence. Each participant was given 15 min to tell his or her story. At the end of the study, there was an increase in happiness and the experience, as noted with other group interventions, was positively received by the participants.

Individually-based Intervention Approaches

The Savoring intervention (Smith and Hanni 2019) was developed as a way to help individuals focus their attention on positive experiences and to modify one's thoughts and behaviors to intensify positive reactions and feelings. The participants are given homework and asked to take 5 min in the morning and 5 min in the evening to complete the positive experiences activity for 1 week. Specifically, participants were told to think of something that was positive and describe a positive experience. The participants were encouraged to appreciate the experience and think about what it was that made the experience so special. At the end of the 7-day period, 46% of the participants completed the full intervention (i.e., did the exercise twice a day as recommended). There was improvement in resilience among those who did the exercises.

The Strength-Focused and Meaning-Oriented Approach to Resilient and transformation (SMART) (Chan et al. 2006) was an earlier intervention that used a multifaceted approach, including Eastern spiritual teaching, physical techniques, such as yoga, and cognitive behavioral interventions and education. Unfortunately, this

approach has not been tested in terms of efficacy and it is not practical as it is time-consuming and costly and requires highly trained therapists.

Conclusion

Resilience is central to successful aging and adjustment to the many changes that occur throughout the lifespan, both those that are normal age-related changes and those associated with common comorbid conditions or acute events such as a hip fracture or stroke. Some individuals may be genetically predisposed to be resilient. Others may develop resilience through life experiences or via focused interventions. Interventions to strengthen resilience include processes such as strengthening general self-efficacy and self-esteem, engaging in social activities and interactions, using humor and maintaining an optimistic attitude, accepting change and looking for ways in which to make the change a growth experience, reaching out to others for support and help, giving back to others, integrating a spiritual and/or creative component to your life, among others. Deliberately trying to strengthen one's resilience can result in significant benefits with regard to physical health as well as psychological health and may even buffer the impact of disease and decrease morbidity and mortality. This requires an understanding of resilience trajectories as dynamic multi-level processes that are shaped by life circumstances and events, opportunities, and resources at the individual, family, and community levels.

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Resilience in Later Life: Responding to Criticisms and Applying New Knowledge to the Experience of Dementia

Gill Windle

Abstract The twenty-first century has seen the concept of resilience as applied to later life becoming increasingly well-established in research, policy and practice. Proponents of the concept argue resilience research challenges stereotypes of aging, an important consideration in societies faced by ageism and discrimination. It has shown how some older people are able to 'beat the odds', providing insights into adjustment processes that might be generalisable to others experiencing difficulties. Counter to this, however, are criticisms of resilience; that it is difficult to define and measure and so impossible to be accurately targeted by services. A further criticism relates to some of the interpretations (and misinterpretations) of resilience by governments and services. Public health policies increasingly place the responsibility for health on the individual, as if we can somehow build superhuman people that will withstand all manner of difficulties. In this article, I provide a general overview of some of these challenges we face as researchers and suggest some tentative solutions, albeit these are still open for debate.

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G. Windle (*)
DSDC Wales Research Centre, Bangor University, Bangor, Wales

Wales Centre for Ageing and Dementia Research, Bangor, Wales

Fron Heulog, School of Health Sciences, Bangor University, Bangor, Gwynedd, Wales
e-mail: g.windle@bangor.ac.uk

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Why Are We Interested in Resilience in Later Life?

Across the world, many people are living longer than ever before. For some, increasing longevity is accompanied by new opportunities, but, for many, later life is associated with an increased risk of ill-health; "evidence that increasing longevity is being accompanied by an extended period of good health is scarce" (Beard et al. 2016). In developed nations, this has been described as an 'epidemiologic transition', reflecting the decline of infectious and acute diseases and a growth in chronic and degenerative diseases and co-morbidity (World Health Organisation 2011). Fifty-two million citizens of the European Union aged 55–74 report having a long-standing illness or health problem; about half of all people in this age group (Harbers and Achterberg 2012). Data from the World Health Organisation (2015) indicate the greatest causes of years of living with disability in people over 60 years (in order of decreasing burden) are sensory impairments, back and neck pain, chronic obstructive respiratory disease, depressive disorders, falls, diabetes, dementia and osteoarthritis. Alzheimer's Disease International (2015) estimate that 46.8 million people worldwide are living with dementia in 2015. It has been estimated that this number will almost double every 20 years, reaching 74.7 million in 2030 and 131.5 million in 2050. This is recognised as a global health challenge and a public health priority (WHO 2012, 2017). The reality of health status in later life does not reflect the traditional model of 'successful aging', where the avoidance or low probability of disease is a prerequisite to a 'good older age' (Rowe and Kahn 1997).

Yet many older people with health problems such as chronic and degenerative conditions do not necessarily see these as a barrier to a good older age. Rather than the presence or absence of disease, the most important consideration for an older person is likely to be their functioning (Beard et al. 2016). A regular research finding is the well-being paradox, which finds some older people, despite declining health status, reporting their health as good (Windle 2009) or report positive psychological functioning (Staudinger et al. 1999). These discrepancies between actual and perceived health status are increasingly being suggested as indicative of resilience in older age (e.g. Ryff and Singer 2009), indicating positive adaptation and management of a major later life challenge. Consequently, the concept of resilience is useful for examining the experience of overcoming difficulties such as illness in later life, since illness is a common reality of aging, rather than the unrealistic complete avoidance of illness that will affect only a minority of the aging population. Considering later life experiences through a resilience lens also adds to the changing perception of what we mean when we define 'health'. Huber et al. (2011) challenged the WHO definition of health as 'complete physical, mental and social well-being', arguing it is no longer fit for purpose due to the increases in people living with chronic disease and their ability to 'function with fulfilment and a feeling of wellbeing' (p. 2). They propose that health is not the absence of illness but a dynamic multi-level process, and that being physically, mentally or socially healthy

is due to the ability to adapt and self-manage whilst living with illness (Huber et al. 2011). Since a key attribute of resilience is an ability to manage and adapt to adversity, it plays a key role in this new perspective of health. Understanding the processes by which people continue to function positively and 'live well' in the face of health challenges is of interest to policy-makers worldwide.

The Development of Resilience Research

The historical timeline of resilience research in younger populations has been described as 'four waves' of activity and theoretical development (Masten 2007), and is a useful point of reference to compare against the subsequent developing of resilience research in older age. These four waves are strongly associated with the field of developmental psychology. In younger people (where the predominant amount of resilience research has been undertaken), the first wave of research was largely built on the investigation of children at 'high risk' for mental illness due to their circumstances, such as childhood trauma or neglect, and an interest in how to prevent or ameliorate risk. This basic research sought to define, measure and describe resilience. Despite variability in how resilience was measured, these studies consistently showed that many young people in high risk situations did not develop mental illnesses. This led to a focus on understanding more about this phenomenon, which was termed resilience, and entailed exploring aspects of the child, their family and wider environment that enabled resilience (Masten 2007). The second wave then sought to explore and test the theoretical processes hypothesised to operate behind the factors identified in wave 1, for example, attachment processes in relation to the role of the family in resilience. The third wave tested resilience theory through interventions to promote protective processes, prevent decline and foster resilience in children. The fourth wave consolidated much of the work from the previous three into integrative, multi-disciplinary explorations across multiple levels, recognising the interrelationships between aspects of the individual and their wider environment (Masten 2007).

Similar patterns of investigation are observed in gerontology; however, in contrast, the interest in resilience as applied to later life, whilst growing, could still be regarded as an area under development when compared to the well-established body of resilience research on younger populations; far less is known about resilience in later life compared to childhood resilience (e.g. see reviews by Bennett 2015; Windle et al. 2011). Nevertheless, the field is making parallel advances 'across the waves'. Moreover, as the field has developed, researchers began to investigate not only the avoidance of disease and mental illness but also the presence of positive outcomes such as well-being (Wild et al. 2013).

What Is Resilience?

One of the common criticisms of resilience has been that it is difficult to define, with a wide array of concepts and operational definitions applied in the literature (e.g. Masten 2007; Windle 2011). If there are issues around how resilience might be defined, then this will also lead to variations in how resilience is identified and measured, raising further difficulties in synthesising and comparing research. Issues pertaining to conceptualisation and measurement may be less relevant for practitioners and service providers whose focus is primarily therapeutic, but traditional scientific approaches emphasise precision and conceptual clarity as preconditions for empirical studies (Strunz 2012). Moreover, if services for older people are claiming to foster the development of resilience, they need to be able to identify and measure it, especially when funding for services requires the demonstration of metrics for sustainability. As an example, a review of resilience research reporting prevalence data noted that the proportions found to be resilient varied from 25% to 84% reflecting sample demographics, and how resilience was defined and measured (e.g. number and type of outcomes) (Vanderbilt-Adriance and Shaw 2008). Variability is also seen in the intended use of the word resilience, for example, a goal, a buzzword, a metaphor (e.g. for mobilising collaboration between people and organisations who traditionally do not work together), which can further complicate and dilute the meaning and usefulness. However, this diversity, in the use of the term, could also be a strength; resilience is studied across many disciplines and so is a concept that has huge interdisciplinary appeal.

Resilience as…	Purpose
Goal	To determine what to aim at
Analytical tool	To understand the problem and find better solutions
Metaphor	To help break disciplinary or sectorial silos
Indicator	As a part of developmental objectives and sustainability
Heuristic	As a basis for modelling or describing a system
Buzzword	As a strategy (e.g. to publish or attract funds)
No use	Used in name only

Source: Tanner et al. (2017)

Nevertheless, recognising the need to clarify the meaning of the concept of resilience from a multi-disciplinary perspective for use in researching populations across the life-course was tackled by The Resilience and Healthy Aging Network. This group of academics, service providers and older people (members of the public) came together in 2008 through funding from the UK Medical Research Council. A number of approaches were applied to understand resilience. First, the team discussed it within project meetings. Second, a review of over 270 published articles of resilience across the lifespan and across disciplines was undertaken using the method of concept analysis, an approach applied to clarify meanings and develop operational definitions, through considering evidence from multiple disciplines

(Windle 2011). This method focusses on identifying the antecedents (events that must happen for the concept to occur), defining attributes (aspects frequently associated with the concept) and consequences the end-points that occur as a result of the antecedents and attributes). Third, consultations with a range of stakeholders and older people enabled them to contribute to the debate over how resilience should be defined. Bringing in the 'lived experience' of resilience in later life alongside academic endeavours is an important consideration. Huisman and colleagues (Huisman and Klokgieters 2017) note that in addition to being clear about 'what' resilience is, we should also consider 'who' should define it. As Canvin et al. (2009) remark in their study of resilience in households facing economic disadvantage "what do people living in adversity themselves count as achievements against the odds that they face?"

In the activities of the Resilience and Healthy Aging Network, older people were asked the following questions:

1. How you would define resilience?
2. What factors from your experiences (work or life) you feel may enhance resilience?
3. What factors from your experiences (work or life) you feel may be detrimental to resilience?

They drew on their own experiences, providing a wide range of responses (some examples below)

- "resilience is like a bouncing ball – a resilience person bounces back and keeps going"
- "motivation is part of resilience – not feeling too old to try something new"
- "important to be open to new ideas and experiences".

Based on the synthesis of the concept analysis derived from the published literature and personal experience, the following definition was developed:

> Resilience is the process of effectively negotiating, adapting to, or managing significant sources of stress or trauma. Assets and resources within the individual, their life and environment facilitate this capacity for adaptation and 'bouncing back' in the face of adversity. Across the life course, the experience of resilience will vary.

Understanding How Resilience Is Attained

The concept analysis also identified three necessary requirements for resilience: (1) there must be a significant difficulty or risk; (2) in the face of the difficulty or risk, individuals continue to function well and avoid a negative outcome; and (3) this process is realised as the presence of assets or resources that can offset the effects of the adversity. In relation to the first requirement, the interpretation of risk is somewhat subjective, as what may be a risk for some individuals may be less so for others. Thus, risk must be something that would ordinarily pose a major threat to

functioning. In later life, for example, these could be bereavement, socio-economic disadvantage, or chronic and degenerative health conditions, as previously described. In relation to the third requirement, these processes are often described conceptually as the resilience reserve (see Fig. 1) or, statistically, as protective factors, and add to the explanation of *how* resilience occurs. Importantly, these are not purely individual level characteristics. For younger people, a consistent pattern of protective factors has emerged across diverse studies. These represent aspects about the person, their psychological resources, their immediate environment and the broader structures (See Masten 2007 for details).

Similarly, contemporary research considers resilience in later life as a process of interdependence between the individual and the wider environment, in which aspects of the environment can enable the personal strengths to adapt and manage. Reflecting the three requirements for resilience, in some of our earlier work, we considered the context of caregiving (Windle and Bennett 2011). The physical, social, psychological and financial pressures of caregiving are regularly associated with poor physical and psychological outcomes (Sörensen et al. 2002), and indeed the literature at one time was particularly dominated with the burden model of caregiving. However, not all caregivers experience poor outcomes, and in relation to the conceptual aspects of resilience, and inspired by the ecological theory of human development (Bronfenbrenner 1979), we developed a theoretical framework (see Fig. 1). The framework acknowledges that the associations of, and resources for, a good outcome despite adversities (i.e. protective factors or assets) are operationalised across multiple levels (micro/individual, meso/community, macro/wider society). The framework aims to understand people in the environments in which they live and to evaluate their interactions with these environments.

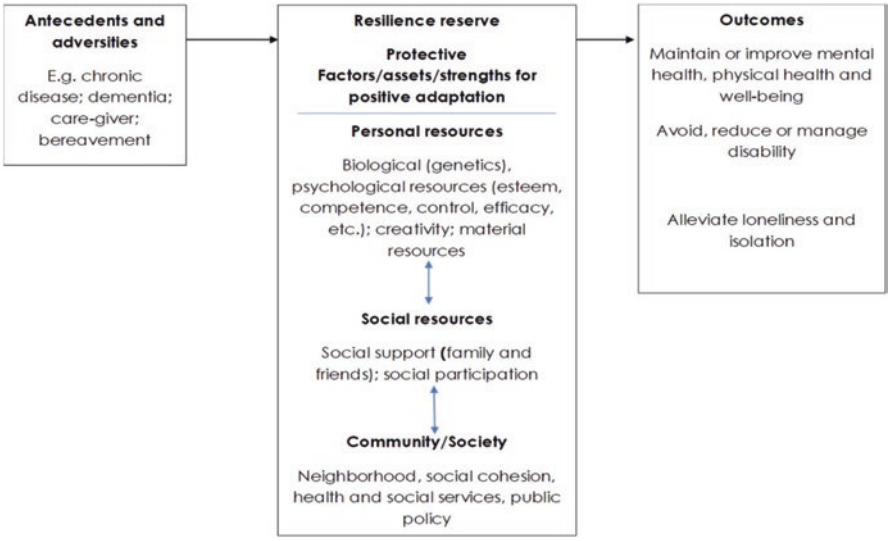

Fig. 1 Resilience framework. (Adapted from Windle and Bennett 2011)

The framework has received limited application in quantitative research, with one study using the framework to examine the resilience of family carers of people living with dementia (Joling et al. 2016). Wider use of the framework can be seen in qualitative studies that focus on discrete areas of adversity and have identified distinctive risk or protective factors in relation to these areas of adversity.

For example, Donnellan et al. (2015) used the framework to explore how spousal dementia carers can achieve resilience. They drew on the definition described previously (Windle 2011), as well as qualitative research on bereaved carers (Bennett 2010) to operationalise resilience in terms of (a) there must be a significant challenge, in this case caregiving; (b) there must be no obvious sign of (di)stress; (c) maintenance of a life of meaning and satisfaction (a sign of bouncing back); (d) active participation in life (a sign of managing) and e) current life must be seen as positive (a sign of adaptation).

They found that caregiver resilience was supported by the carer staying positive, maintaining their relationship with their spouse, being knowledgeable about dementia and being well-supported by family, but especially friends, with whom they shared this knowledge. Resilient caregivers were more actively engaged with formal services such as respite care. Donnellan et al. (2016) explored social support as a component of resilience for older spousal dementia carers. They found that support from family and friends served a range of functions that facilitated or hindered resilience and they facilitated resilience only if they are perceived to match need. Participants were less likely to resist support from grandchildren due to their relatively narrow and low-level support functions. In another application, Bennett et al. (2016) used the framework to understand the individual, community and societal factors that influenced the resilience of older Columbians living in poverty. Their analysis supported some of the psychological, community and societal factors in the original framework (Windle and Bennett 2011), but also highlighted some new factors. These included the importance of religion for resilience, and the role of violence and displacement for undermining resilience. Furthermore, two new themes for the framework—the relationships of the health professionals with the carers; and the families' relationships with each other—were identified in an exploration of how aspects of the resilience framework influenced the social support that enabled the resilience of family carers of people at the end of life (Roper et al. 2019).

A study by Newman et al. (2018) explored the role of visual arts for the resilience of people living with dementia in residential care homes, drawing on the same framework to understand the findings. They found that visual arts activities supported the resilience of those with dementia through enabling creative expression, facilitating increased communication, improving self-esteem and positively influencing relationships between people living with dementia and their carers and family members. They also suggest that even those with advanced dementia can demonstrate resilience, which can be supported by, and explored through, visual arts activities. Han et al. (2019) utilised the framework to explore caregiving challenges, solutions (resilience resources) and expected consequences in family carers of hospice patients with dementia. They found that caregivers defined as 'resilient' described resources across the individual level (self-control and positive appraisal

strategies, self-care); the community level, such as having options to choose a good care facility which is homelike and dementia-friendly with trustful, respectful providers and staff, having the support of family or friends and involvement in volunteer activities; and with wider society level resources identified such as legislative support, increasing public awareness and appropriate health insurance.

As a relatively recent development, the framework requires ongoing investigation and further modification, but to date its utilisation in gerontological research highlights how different levels of functioning are important for resilience in the aging process. Elsewhere, while some differences remain, gerontologists interested in resilience in later life share thinking around some aspects of the conceptualisation of resilience, contributing to the advancement of theory. For example, Wiles et al. (2012) qualitatively explore resilience in older people in New Zealand. They found that internal or personal characteristics of resilience, such as positive attitude or purpose in life, were deeply embedded in social and environmental contexts that could underpin or undermine resilience. They argue that 'resilience should be understood as a contextualised process which can be both individual and environmental'. Their analysis further highlights the importance of state funded services for an ecological resilience framework. Wild et al. (2013) examined the utility of the concept of resilience for critical gerontology. They suggested some key principles for its use, notably that individual resilience should be situated within other levels of resilience, such as neighbourhood, community and society, recognising the interdependence between the different levels of older people's lives. In Canada, Wister et al. (2016) reviewed and synthesised the literature to suggest a life-course model of multi-morbidity resilience. This represents a set of risk or protective traits, resources and processes that occur over the life-course to promote resilience (see Fig. 2), adding a fifth wave of resilience activity to the four outlined by Masten (2007).

Taken together, gerontologists have substantially developed the evidence base for resilience in later life to be defined as a dynamic process across multiple-levels, identifying a range of factors important for a good outcome, reflecting the fourth wave of resilience research in young people identified by Masten (2007). Moreover, the theorising about resilience by gerontologists emphasises two aspects. First, the responsibility for resilience does not reside purely within the individual, and second (and important to those of us who study aging)—the life course. Earlier work from the Berlin Aging Study (Staudinger et al. 1995) also situates resilience in the lifespan, where internal psychological resources and external resources such as social networks form the reserve capacity that prevent considerable changes in well-being, and resilience is the process of utilising these reserves. Considering resilience from a life-course perspective also presents the opportunity for what Wister et al. (2016) describe as a resilience trajectory, where prior experiences with challenges may influence the ability to adapt positively in later life. Rutter (2012) describes this as a strengthening or 'steeling effect', suggesting that *"exposure to stresses or adversities may either increase vulnerabilities through a sensitization effect or decrease vulnerabilities through a steeling effect"* (p.337). In support of this proposition, Seery, Holman and Sliver (Seery et al. 2010) examined cumulative life-time adversity and resilience in a longitudinal study of 2398 people aged between 18 and

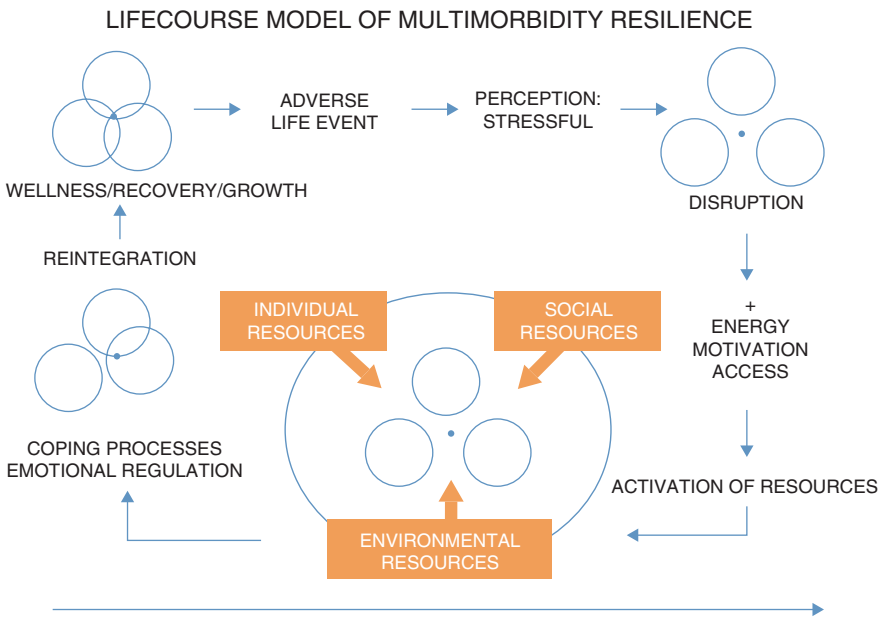

Fig. 2 Life-course model of multi-morbidity resilience. (Source: Wister et al. (2016)

101. They found that the experience of some lifetime adversity (e.g. own illness or injury, loved one's illness or injury, bereavement, serious financial difficulties, living in dangerous housing, relationship stress such as experience of divorce, and disasters such as major fire, flood, earthquake, or other community disaster), predicted better mental health and well-being outcomes when compared to people with a history of high levels of adversity, and also people with no history of adversity. They conclude that "*in moderation, whatever does not kill us may indeed make us stronger*" (p. 1098).

Measurement—Operationalising Resilience

Despite gerontologists having made advances in how we understand and define resilience, moving this into measurement is not without challenges. In younger populations, resilience measurement tends to focus on the healthy development of the individual, the extent to which developmental milestones and challenges are successfully achieved, and the development of competencies. At the other end of the life-course, the skills and competences developed earlier in life are now required for application to situations that are more common in older age, such as the bereavement of a spouse or chronic and degenerative illness. Qualitative research is very revealing when exploring the complexities that might facilitate or hinder resilience in later life, as noted in the previous section.

But how might this translate this into quantitative measurement? Fortunately, there are some solutions to this issue. Reviews of the different ways resilience is operationalised in longitudinal studies (Cosco et al. 2017) and the study of later life (Cosco et al. 2019) are excellent points of reference for those wondering which direction to take with study design and data collection. These are discussed in more detail in Chap. 6, and two of these are further discussed here. These two approaches to measuring resilience may be particularly appropriate for the researcher or practitioner who may not have advanced statistical skills for analysing data.

The first thought for many of us will be to use an existing measure of resilience. But which one? A systematic methodological review of resilience scales identified fifteen measures, noting that most researchers measure resilience at the individual level, focussing on psychological resources/strengths. (Windle et al. 2011). Only five measures examined resilience across multiple levels, reflecting conceptual adequacy. Of these, only one measure—the Resilience Scale for Adults—was viewed as potentially appropriate for older people, as the others were originally developed for application with younger populations (Windle et al. 2011). Consequently, most measures of resilience do not fully capture the theoretical understanding of resilience as the interdependence between the individual and their environment. Nevertheless, some of the scales of individual/psychological resilience are now widely used by gerontologists. Cosco et al. (2016) systematically reviewed the literature and examined the reliability and validity of resilience scales that had undergone psychometric examination in older populations. They report three measures of individual resilience that were regularly used by researchers; The Resilience Scale (Wagnild and Young 1993), the Connor-Davidson Resilience Scale (Connor and Davidson 2003) and the Brief Resilient Coping Scale (Sinclair and Wallston 2004). However, they concluded that further research is required to contribute evidence regarding the utility of resilience measures or to develop new resilience measures specifically for use in older populations (Cosco et al. 2016).

This is especially relevant for research and practice, as measures of individual resilience are relatively easy to administer and have shown, for example, the importance of resilience for:

- Mitigating the impact of ill-health on well-being (Windle et al. 2009)
- Reducing the impact of a new chronic condition on disability (Manning et al. 2014)
- Adjusting to multiple chronic conditions (Jason et al. 2015)
- Moderating the impact of daily stress on negative emotions (Ong et al. 2006).

A second approach outlined by Cosco and colleagues (2016) overcomes some of the limitations posed by resilience measures. This ‘definition driven’ approach is often used by resilience researchers who work with secondary sources of longitudinal data, which may not contain a resilience measure, but often have considerable data available to hypothesise some of the interrelationships between the individual and their environment. This enables researchers to test which aspects of the resilience reserve may be important for a resilient outcome. With this method, the researcher defines the criteria for resilience, informed by the relevant theory. Here,

the evaluation of resilience should take into account both the difficulty and the outcome of interest, reflecting the first two requirements for resilience previously described. A review by Chmitorz et al. (2018) stresses the importance of distinguishing between resilience factors and resilience as an outcome and recommends the use of different measures for a complete assessment of resilience.

For example, Joling et al. (2016) utilised data from four different studies across two countries to investigate resilience among dementia caregivers. The integrated data set included 15 harmonised variables with data from 1048 caregivers facing a high care demand. Resilience was conceptualised as a relatively high level of psychological well-being in the caregiver ('a positive outcome') despite various substantial demands that occur directly in the context of dementia care, such as caring for a relative with more severe dementia, self-care limitations, behavioural problems or providing substantial amounts of care ('adversities') and an outcome measure created from the data to reflect this conceptualisation. With this measure of resilience, 39% who were facing more than one caregiving demand were deemed resilient. High resilience was least prevalent when behavioural/mood problems in their relative were reported (34%). Following that, the determinants of this measure of resilience were explored to understand what aspects of the caregivers' lives might support a good outcome. Not all of the variables were available across the four studies (15/24), but of those that were, being a male caregiver, caring for a female, living apart from your relative, lower perceived burden and a good quality relationship were positively related to caregiver resilience. Of the variables that could not be harmonised, a better sense of competence, greater mastery and fewer feelings of loneliness in the caregiver were of significance for resilience. Fewer feelings of guilt and greater social support were also important for some of the adversities.

The analysis by Joling et al. (2016) demonstrates the utility of a measurement approach more closely tied to a conceptual understanding of resilience and, furthermore, suggests key areas that could be targeted in an intervention. Of course, a major limitation of this approach is that theoretically important data may not be available, as is often the case when working with secondary sources of data. But this approach to measurement is not beyond the statistical skills of most researchers who employ quantitative data.

Resilience and Living with a Dementia

According to Alzheimer's Disease International (2015), every three seconds, someone in the world develops a dementia. There are many different types of dementia, and Alzheimer's Disease is the most common, followed by vascular dementia, dementia with Lewy bodies and fronto-temporal dementia (WHO 2012). Mixed dementia is also common. Although increasing age is the main risk factor for a dementia, the condition also presents in middle age in people in their 50s and 60s. The symptoms of a dementia vary, but clinically present as a mixture of some of the following; memory problems, difficulties with speech and communication, recogni-

tion and coordination difficulties, disorientation, mood, judgement and behaviour changes, difficulties with functional activities of daily living. The global societal-economic costs of dementia, estimated from the direct medical costs, direct social care costs (paid and professional home care, and residential and nursing home care) and informal (unpaid) care costs are a staggering US$ 818 billion (ADI 2015). In the face of limited medical treatments and the absence of a cure for dementia, understanding what might enable people to live as well as possible is of global relevance. How (if at all), can we be resilient when facing a life-changing, degenerative condition, namely, dementia? To date, very little work has examined resilience in relation to the lived experience of dementia, so there are many questions currently unanswered. This imbalance is being addressed in the work programme by DSDC Wales Research Centre at Bangor University, where we are exploring what resilience means when facing dementia, from the experiences of those living with dementia and those supporting them.

The first point to consider is the definition of resilience within the context of dementia-related adversity. Definitions of resilience often refer to the idea of 'bouncing back'. Whilst this might be intuitively considered an aspect of resilience, to what extent is it appropriate when considering life-changing, degenerative conditions, such as dementia? In 2018, in a workshop with 46 delegates (people living with dementia, their carers and practitioners), we had a very revealing discussion, promoted by the following questions.

- What is resilience? What does it mean to you?
- What do you feel promotes resilience when faced with dementia? What do you feel is helpful?
- How have you overcome challenges when faced with dementia?
- What would you recommend to support resilience when faced with dementia?

The session was a lively and often frank conversation about the many challenges faced, but also the many strengths people possess. A cautionary note or two were articulated, especially a need to ensure that resilience does not become understood as an "expected norm", resulting in people being left unsupported by services. The notion of 'bouncing back' was discussed, encapsulated by the quote from a carer, who remarked (see Fig. 3), "*but you can never bounce back the same as you were, it's not possible when going through this to be the same"*. In a recent discussion about resilience with four people living with early onset dementia and their family carers, when asked to consider 'bouncing back' in relation to dementia, one commented *"you bounce somewhere else; you pick yourself up"*. Another remarked *"I can never bounce back and I feel resentful I've been dealt this hand, but you want to make the most of it for family, so go off and do things and make memories"*. These early indications suggest the 'bouncing back' aspect of resilience definitions may require modification, and our current work is examining the limited published research and undertaking interviews and workshops with people living with dementia and their carers, to build up a theoretical framework of resilience in relation to

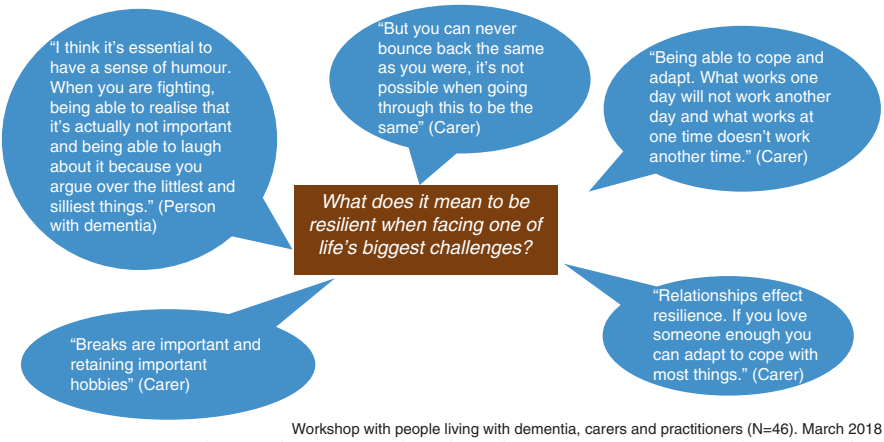

Fig. 3 Reflections of resilience in relation to dementia

the lived experience of dementia. Resilience and living with a dementia are further discussed later in this chapter on pages 46–47.

Resilience and Health Policy

The World Health Organisation has been at the forefront of transforming the policy expectations of older age, challenging the disproportionate representation of older age as one of decline and frailty. This was set out in Active Aging, a Policy Framework (2002), Global Age Friendly Cities (2007) and more recently in the World Report on Aging and Health (2015), the Global Strategy and Action Plan on Aging and Health (2017) and the Global action plan on the public health response to dementia (2017). The 2015 and 2017 aging and health outputs are particularly relevant when thinking about resilience. These were developed in response to recognised diversity in later life health experiences; such that while many older people are engaged and socially active, and reaching extreme ages, a significant proportion experience poor health. The environments in which we live and the level of embedded social, financial and human resources can support or undermine individuals' physical and psychological capacity, and ultimately how they respond to life events and health challenges.

These were developed in response to global trends in aging, recognising diversity in later life health experiences. Although many older people are living longer, and are engaged and socially active, a significant proportion experience poor health. The policies recognise the environments in which we live and the availability of

support and services can maintain or undermine a person's physical and psychological capacity and ultimately how they respond to life events and health challenges.

In developing this public health response to support healthy aging, the WHO note "*It is important not just to consider approaches that ameliorate the losses associated with older age but also those that may reinforce recovery, adaptation and psychological growth"* (2015, p.25). Resilience is incorporated in this policy, describing the ability to maintain or improve a level of functional ability in the face of adversity (either through resistance, recovery or adaptation), and for supporting older people to navigate and adapt to the losses they are likely to experience through a combination of internal and external resources (2015, p.27). This policy perspective recognises that healthy aging is not just about the absence of disease, and aligns well with the conceptual understanding of resilience as one of an interrelationship between the individual and the environment, and the resilience reserve.

Despite the WHO policy's emphasis on the importance of wider structural aspects of resilience, the interpretation of the meaning of resilience within the development of health policy by regional and national Governments have fuelled considerable debate and criticism. Such interpretations move away from aspects of the WHO policy with its focus on changing the wider structures that enable good health outcomes, to an increasing emphasis for individuals to take responsibility for their own health and well-being. In Wales, for example, a country in the UK, struggling with service cuts through austerity measures, Healthier Wales (2018, p. 7) states that to achieve the vision for longer, healthier and happier lives: "*We need people to take more responsibility, not only for their own health and wellbeing, but also for their family and for people they care for, perhaps even for their friends and neighbours."* This notion of active citizenship and personal responsibility is intuitively appealing to many people, since individuals do not wish to be passive actors in our own destiny. Arguably, however, active citizenship and personal responsibility may be more achievable by individuals who are more resourced and capable in the first place.

Moreover, cultural theorists (e.g. Joseph 2013) argue that the neo-liberal retrenchment practices of governments emphasise personal responsibility in policy to counter reductions in state service provision. At the grass roots level of service provision, building resilience can become misused, 'a buzzword' highly topical and appealing but transferring the focus onto personal responsibility. This emphasis on personal responsibility then leads to a further criticism of resilience—that it may inadvertently further widen health and social inequalities. Gerontologists with interest in resilience regularly work alongside people who are marginalised and disadvantaged due to many of the health, social and economic challenges that manifest in later life. They are acutely aware of the structural challenges faced by older people. So how do we counter the potential misuse of resilience and ensure our services and practices can build resilience that do not lead to inequalities?

Resilience and Social Justice to Negate Inequalities

In the UK, Angie Hart, Professor of Child Family and Community Health at the University of Brighton, has been working for many years at the interface between resilience research and practice. Her work has critically engaged with the concept, especially with respect to inequalities (e.g. Hart et al. 2016). The author's responses are interpreted through a social justice lens and challenge the structures that create disadvantage. This approach can potentially unite resilience research and practise development with social justice and activism. Hart et al. (2016) view resilience as not just overcoming an adversity, but also "*potentially subtly changing, or even dramatically transforming (aspects of) that adversity*" (p. 6). They use an example of an intervention that may contribute toward systemic change, such as changing a school policy that enables a supportive culture that discourages discrimination, whilst at the same time delivering activities to build resilience in children to help them deal with stigma and bullying.

Many gerontologists also embed co-production within their work. In relation to the introduction earlier in this chapter about resilience and living with a dementia, in Wales, the author's research centre hosts a network for a wide range of stakeholders, including those living with dementia. A number of the members living with dementia have developed into advocates for the rights of people living with dementia, speaking out at local, national and international events, representing examples of resilience through social justice. Some have set up their own peer support scheme called 'Friendly Faces'. This was developed in response to their perception that when first diagnosed, many individuals lacked the confidence to initially attend groups for people living with dementia, and so they felt an initial telephone call could help initiate this first step. This intervention offered telephone support to those who are just diagnosed and struggling to come to terms with the impact, helping people see that life goes on, and they can still take part, do things and contribute. As one of the peers stated *"my attitude has changed – I used to always put myself first, now I think about everyone else instead. It helps me to help them. I stick up for myself and other people more."*

Rather than 'bouncing back', which was noted earlier in this chapter as problematic in relation to living with dementia, this social justice approach reflects a more appropriate idea of 'bouncing forward' (Jeans et al. 2016), where we can also change the conditions that undermine our resilience and enhance risk. At the moment, we may not be able to change whether we have dementia, but the health and care systems that support us can be challenged and changed, as identified as priority action areas in the WHO healthy aging action plan. For people living with dementia, one example is the importance of a 'good' diagnosis, as discussed in a recent (July 2019) workshop on the topic of resilience with people living with early onset dementia. One person remarked: *"Resilience can be destroyed or built up – the person delivering the diagnosis makes or breaks you. We were given a diagnosis and dropped."* Another stated*: "At the point of diagnosis we were left without hope. You don't understand the word hopeless until you are left without hope. Hopelessness*

destroys resilience. Hope was taken away – the diagnoser is critical." So, in our attempts at resilience in practice, we must also attend to the systems that may cause difficulties or be a barrier to overcoming difficulties, to provide the opportunity for individuals to live as well as possible. Some of the workshop attendees worked with us to make a short film of their 'top tips' for resilience in the face of dementia, which can be viewed here http://dsdc.bangor.ac.uk/supporting-people.php.en

Improving Dementia Knowledge

Recognising dementia as global public health priority, the World Health Organisation (2012) directs an area of action towards improving societal understandings of dementia. This is in response to the narrow and negative way of thinking about dementia that is pervasive in society; we are not well informed about what life is like with the condition (e.g. McManus and Devine 2011). This leads to people living with dementia to experience stigma and social exclusion (WHO 2012), and poor care as alluded to in the previous paragraph. Dementia has been described as 'the hidden voice of loneliness' (Alzhiemer's Society 2013). Zeilig (2014) questions the negative metaphors and cultural fear often associated with dementia, discussing words that appear regularly in the media and literature, such as 'tsunami', 'epidemic' and 'burden', and how these provoke fear and marginalisation. Media reports typically focus upon the end stages of dementia rather than the entire trajectory of the condition (Van Gorp and Vercruysse 2012). Swaffer (2015), a person living with a dementia, describes the impact of societal attitudes as prescribed dis-engagement®, reflecting the loss of pre-diagnosis life, arguing that it "sets up a chain reaction of defeat and fear, which negatively impacts a person's ability to be positive, resilient and proactive" (2015, p. 3). This indicates the imperative for community initiatives to break down such barriers. Individuals may be unable to become resilient if the community does not facilitate inclusion, challenging and changing the social attitudes that lead to disengagement.

Around the world, many organisations are actively working to develop dementia-friendly communities, enhancing awareness and understanding of the condition (Alzheimer's Disease International 2017). The Alzheimer's Society initiative 'Dementia Friends' provides short awareness raising sessions to the public, aiming to transform the way society thinks, acts and talks about the condition. To date (August 2019), over 2.5 m people around have become Dementia Friends (https://www.dementiafriends.org.uk/).

As part of a large programme of research at Bangor University, 'Dementia and Imagination', we explored how the arts may facilitate social change, challenging and engaging the public in conversations about living with dementia to improving dementia knowledge. We found that artwork and creative activities effectively engaged a range of audiences and challenged negative ideas about dementia (Tischler et al. 2019). In one activity, we ran art-making workshops for a range of stakeholders, reflecting the art workshops attended by the study participants living

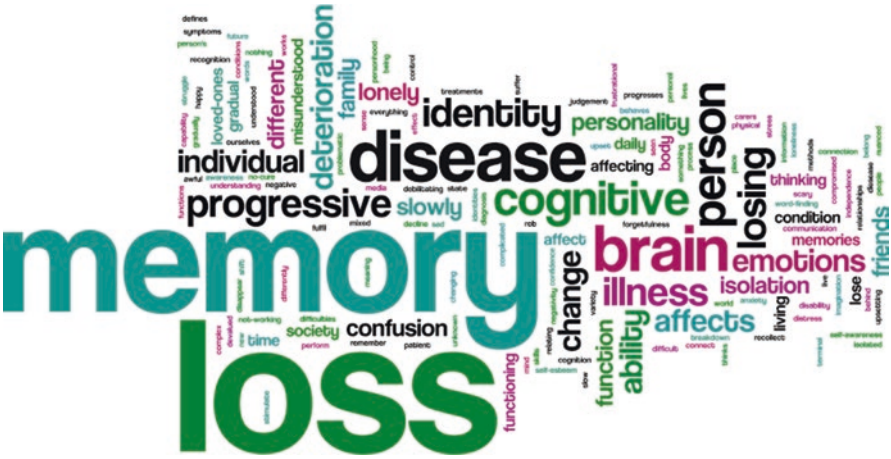

Fig. 4 Wordle before delegates participated in workshops

Fig. 5 Wordle after delegates participated in workshops

with dementia, and showcasing some of the outputs produced by the participants. At the start of the workshops, people were asked to write a word in relation to the statement *'Dementia is…'* captured in the Wordle. The most prominent words used were 'loss' and 'memory' with a number of responses describing the biological process of the condition (Fig. 4).

At the end of the session, 'memory' was still a prominent term; however, 'loss' received less responses with more numerous terms receiving the greater share of responses, including: 'misunderstood', 'individual', 'support' and 'live' (Fig. 5). Small changes, but a subtle shift in perception from the 197 respondents. (Source: Dementia and Imagination Connected Communities Festival 2015 Report).

Interventions to Develop Resilience

The previous sections highlight some of the potential protective factors that could be scaled up into programmes to strengthen resilience that are replicable and can be widely implemented in public health. However, to date, these are currently lacking. After a systematic review of randomised and non-randomised controlled trials of resilience interventions in non-clinical samples, Macedo et al. (2014) concluded that despite evidence to suggest that resilience promotion interventions were effective, the interpretations were hindered by the poor methodological quality of available studies. None of the included studies were targeted at older people, and all were psychological interventions. Leppin et al. (2014) included some patients with chronic conditions in their review of randomised controlled trials designed to test resilience promoting interventions. They found that many of the reviewed studies used a wide array of conceptualisations in relation to intervention application. Indeed, most of the twenty-five studies utilised psychological therapies and psychoeducation, with one study aiming to help pregnant military wives identify internal and external assets. Although there was some evidence to suggest that the interventions were effective, the authors indicate the studies were poorly specified and lacked theoretical clarity, and none specifically targeted older people.

Joyce et al. (2018) reviewed randomised controlled trials (RCTs) or controlled trials, assessing the efficacy of programmes designed to develop, enhance or improve resilience in adults. However, they limited the inclusion criteria to studies that had used a validated outcome measure of resilience. The identified programmes focussed on individual level resilience, covering psycho-education, mindfulness, cognitive skills, self-compassion skills, gratitude practise, emotional regulation training, relaxation and goal setting, and they concluded that interventions using mindfulness or CBT techniques appeared able to enhance measures of resilience. Unfortunately, no descriptions of the study samples are included, so it is not possible to ascertain if any of these programmes included, or specifically targeted older people.

The reviews indicate that resilience promoting interventions are largely characterised by psychological therapeutic models. The lack of clarity around conceptualisation and measurement within the intervention studies hampered their methodological quality, and all the above authors call for improvement in study designs for intervention testing. Despite potential, resilience interventions have yet to be developed and tested with older people specifically, and have not yet translated into models of service delivery, particularly those living with dementia. Researchers considering intervention development and testing are advised to utilise excellent points of reference to guide their planning, such as the UK Medical Research Council's guidance on the development, evaluation and implementation of complex interventions to improve health (2008) and guidance on process evaluation of complex interventions (2015).

Conclusion

This article has discussed some of the main criticisms of resilience and presented an argument for the utility of the concept for gerontology research and practice**.** It indicates that resilient people need resilient systems in order to age as well as possible despite their difficulties and mitigate against widening health inequalities. This is vital; whilst research indicates that many older people are able to 'beat the odds' and demonstrate considerable resilience, there must be a limit for how much difficulty an individual can withstand. Actions need to come not only from the individual but from the environments around them.

Governments should not be seeking to develop the resilience of its subjects as a way of ensuring people endure situations that should be solved by investment into communities and services. As gerontology researchers, we must ensure that future work on resilience embraces contemporary understanding of resilience as interdependence between the individual and their environment and embed this in the development and testing of high quality programmes to foster the resilience of older people and those living with dementia.

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Science and Practice of Resilience: Disaster Systems Applications to Aging Resilience

Katarzyna Klasa, Stephanie Galaitsi, Benjamin D. Trump, and Igor Linkov

Abstract This chapter adapts the National Academies of Science systems model of resilience to natural disasters to a resilience model for aging adults. After exploring the origins and applications of the term resilience in gerontology, medicine, and public health, we incorporate the components of disaster resilience to present a framework for quantifying resilience for elderly individuals. The recent COVID-19 pandemic reinforces the importance of a system-level resilience approach. By merging transdisciplinary knowledge of resilience using a complex systems approach, we seek to develop a generalized theory for different contexts and populations. While resilience for the elderly can be quantified at the individual level, it must also be contextualized for external structural and system-level factors that influence the types and availability of resources that adults can access to recover from aging-related adversities. Understanding resilience for elderly adults can complement studies that seek to minimize risk, vulnerability, and frailty to improve quality of life and to decrease the burden of care arising from a growing elderly population.

Keywords Resilience · Aging · Public health · Complex systems model · Disasters

Introduction

Around the world, health improvements are allowing more people to live longer. Though partially mitigated by immigration, in developed countries, declining fertility and mortality rates are causing the percent of aging populations to grow in rela-

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K. Klasa
University of Michigan School of Public Health, Ann Arbor, MI, USA
e-mail: kklasa@umich.edu

S. Galaitsi · B. D. Trump · I. Linkov (✉)
United States Army Corps of Engineers, Engineering Research and Development Center, Vicksburg, MS, USA
e-mail: Benjamin.D.Trump@usace.army.mil; Igor.Linkov@usace.army.mil

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tion to younger cohorts who traditionally contribute to their care. By 2050, there are expected to be twice as many elderly adults as children under five (World Health Organization 2018). This demographic shift will have economic, social, and political repercussions as societies negotiate how to provide health care, welfare, and other systems of social protection (United Nations 2019). At the same time, medical technological developments have improved the detection of disease, thereby increasing the need for complex care for people nearing the end of life (Wister and Speechley 2015). This burdens national health systems with the high costs of treating complex patients (Fabbri et al. 2015; Van den Bussche et al. 2011; Barnett et al. 2012; Goldman et al. 2013). Thus, increasing life expectancies must be paired with commensurate advances in illness prevention, adaptation/coping, and resilience to counterbalance the impeding stress that rapid population aging will exert on support systems.

As humans live longer, their chances of developing multiple chronic diseases such as arthritis, cardiovascular disease, cancer, diabetes, depression, and dementia increase (Barnett et al. 2012; Marengoni et al. 2011; Pefoyo et al. 2015). Neurological diseases, in particular Alzheimer's and related dementias, are projected to affect over 100 million individuals worldwide over the next three decades, further increasing the global burden of disease (Brookmeyer et al. 2007; Takizawa et al. 2015; Lehnert et al. 2011). Although many older individuals report 'aging-well,' physical deterioration decreases the ability of older adults to maintain activities of daily living (ADLs) and independent lifestyles (Vermeulen et al. 2011). Worldwide, the elderly are at higher risk of socio-economic deprivation (He et al. 2016). In both urban and rural settings, social isolation and loneliness affect increasing numbers of older individuals and have been associated with depression and mortality (Nicholson 2012; Luo et al. 2012; Holt-Lunstad et al. 2015), and the elderly are affected more negatively by environmental disasters such as pandemics and hurricanes (Bell et al. 2018).

While the older individuals face numerous adversities, some recover more easily and successfully from disruptions than others. These individuals are termed "resilient." Resilience is a theory and a methodology that can be applied to the aging process. Most aging adults face increasing vulnerabilities, meaning that their risks of negative consequences are also increasing even if actual threats and their probabilities remain static. Elderly individuals that display resilience can better maintain or optimize critical functions as they cope with the increased vulnerabilities of aging.

Recently, many scholars and health organizations have begun to discuss the importance of resilience as a factor in successful and healthy aging (Cosco et al. 2018; Pruchno and Carr 2017). Healthy aging is gaining traction as an important public health policy priority. The World Health Organization (WHO) has advocated for a more robust public-health response towards the growing older population, especially in ensuring an individual's ability to navigate through the complex aging process. However, resilience in elderly adults is often conflated with pre-existing health status, producing inconsistencies in its definition and application. Some view resilience as a dynamic process of adaptation against adversity, while others view it as an internal personality trait. Early formulations of resilience have been primarily

psychological in nature, although recent advancements, including in the gerontological literature, have broadened its scope to include individual and environmental domains, life-course temporal dimensions, and applications to specific forms of adversity (Masten 2007; Wister et al. 2016).

Elderly individuals require access to healthcare services, safety, social support, and adequate knowledge and education to optimize their capacities throughout their lifespan. Without these resources, older individuals are less able to prepare and respond to a significant disruption in their life or health. While this broad base of needs is reflected throughout the gerontology literature, there remains considerable diversity in how to model or quantify resilience (Cosco et al. 2019; Windle 2012; Angevaare et al. 2020). There is also an absence of a generalized theory of resilience that can be applied to different contexts of aging. These gaps may be filled by employing developments in disaster resilience using complex systems theory. Here, resilience is conceptualized as a system property, but the system in question can change depending on the scale of analysis. The following sections will (a) review the full range of resilience literature; (b) examine the application of this concept within the intersecting sub-fields of medicine, public health, and gerontology; and (c) use a complex systems formulation that emerges from disaster resilience literature to propose resilience metrics and an integrated model that can be applied to older adults in future research.

Resilience to Disasters and System Disruptions

In disaster research, the term resilience characterizes complex systems such as environmental habitats, cyber domains, and critical infrastructure, as well as physical and psychological functions for humans and communities. This latter social category shares many features with traditional systems of resilience, most notably that a subject may demonstrate resilience only upon experiencing hardships. This distinguishes resilience from other metrics such as risk and vulnerability, which seek to understand the likelihood and potential damage of experiencing hardship. At its simplest, risk is "the possibility of loss, injury, or other adverse or unwelcome circumstance ("risk, n." 2019)." Vulnerability is "the quality or state of being exposed to the possibility of being attacked or harmed (vulnerable, adj." 2019)." Resilience characterizes the system's response to harm after it has occurred.

The National Academies of Sciences (NAS) has defined disaster resilience as "the ability to plan and prepare for, absorb, recover from, and adapt to adverse events (National Research Council 2012)." The NAS definition incorporates uncertain, consequential risk events that are not easily addressed using traditional risk management approaches. Preparing for adverse events can include reducing risk and vulnerabilities, but resilience also measures the system's response to threat, particularly its ability to absorb a hardship and recovery from it. Such an ability assumes increasing importance when certain risks and vulnerabilities cannot be wholly avoided within feasible cost margins. Limitations or shortcomings exist in

almost any designed security, and in circumstances when hardships arise despite existing protections, resilience provides another process to safeguard critical functions over time.

Resilience as a system component is independent of measures of risk. Risk incorporates the size of a potential threat, the vulnerability of the subject system, and the consequence expected should the threat occur. Together, these risk components will determine the adverse consequence on the system as it absorbs the disruption, meaning as its critical function declines under pressure. Resilience is the opposite force that pushes the critical function to return to full capacity after a decline. Resilience's contribution to system management is not its ability to protect, but to restore (Fig. 1).

Figure 1 uses the NAS definition of disaster resilience to show the influences of risk, vulnerability, threat, and consequences that determine the magnitude of system disruption, and the system resilience that returns functionality to its original level (Linkov et al. 2014).

Systems with high resilience persevere when disruptions and hardships materialize. Though system managers prefer to avoid negative consequences wherever possible, the long-term viability of the critical function of a system must not rely on avoiding the unavoidable, but on its assured recovery that reduces downstream or long-term damages. Figure 2 shows the interactions between disruptions (realized risk) and resilience of differing intensities.

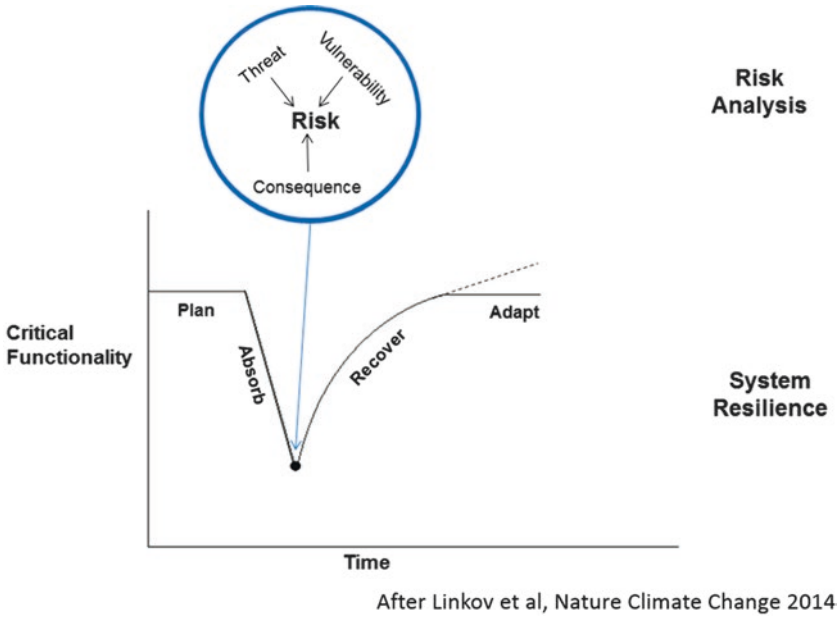

Fig. 1 Risk, resilience, and vulnerability in the process of system disruption

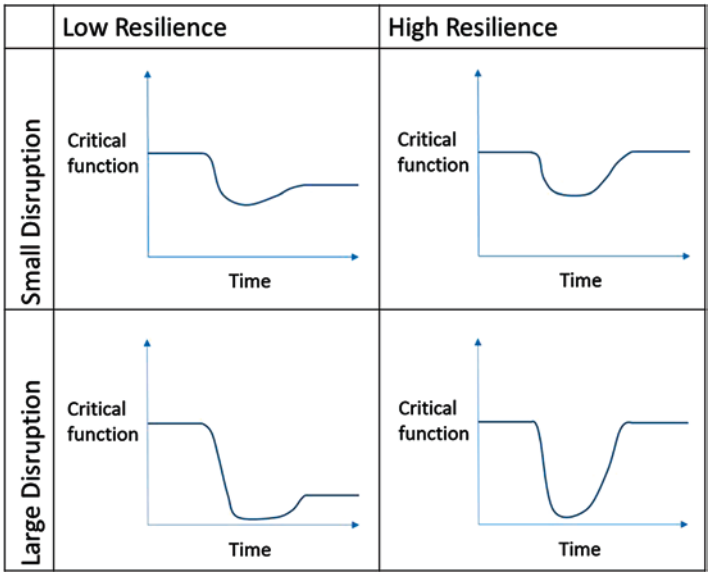

Fig. 2 Interaction between risk and resilience

The NAS resilience model can be applied to gerontology and aging because its constituent parts (planning, absorbing, recovery, adaptation) can be applied to support elderly resilience (Linkov and Trump 2019). Planning can include healthcare provider access, transportation, social support networks, socio-economic support, access to healthy foods, opportunities for physical activity, healthcare facilities and capacities to provide care, and even safety. Many planning aspects fall under general healthy behavior, but preparations can also seek to increase individual capacity to recovery after a disruption. Following the disruption, the resilience in the absorption and recovery process can help elderly adults attain their previous levels of health or otherwise expected levels within the previous health trajectories they had been following, including decline. Figure 3 shows how the NAS model of resilience could be applied to a declining critical function for positive outcomes.

Aging is an unpredictable life process. Risks to health and well-being cannot always be anticipated and they are difficult to quantify. Successful—dubbed "resilient"—individuals recover from disruptions and learn to adapt to them for the future. In order to evaluate and improve resilience for elderly individuals, researchers and practitioners need methodologies to quantify it according to established metrics.

With the growing importance of resilience concepts to complex systems, researchers have explored resilience metrics and quantifications. Kott and Linkov (2019) differentiate between metrics-based and model-based resilience measurements, which themselves overlap (Fig. 4) (Linkov and Kott 2019).

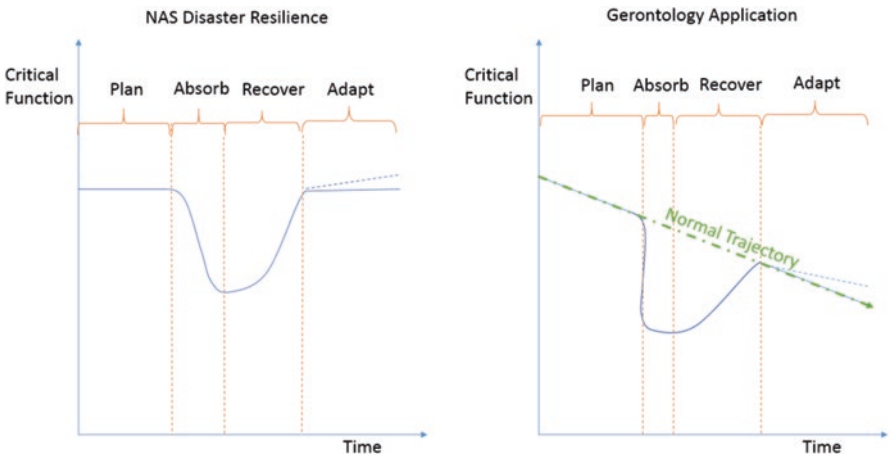

Fig. 3 Applying national academy of science resilience model to gerontology

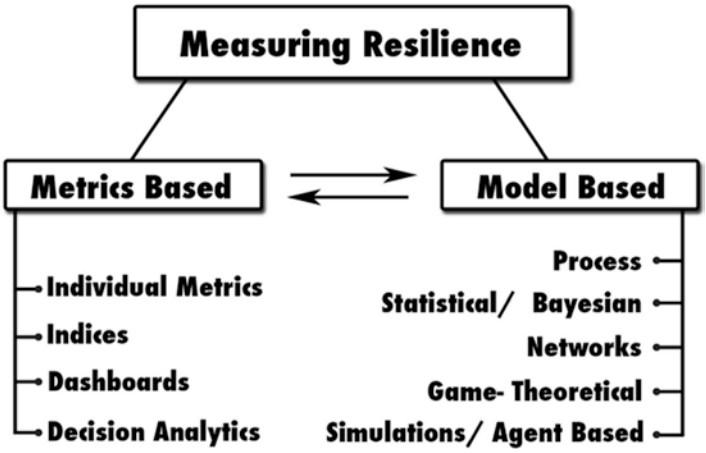

Fig. 4 How to measure resilience. From Linkov, Igor, and Alexander Kott. "Fundamental concepts of cyber resilience: Introduction and overview." In *Cyber resilience of systems and networks*, pp. 1–25. Springer, Cham, 2019

Metrics-based approaches construct the system as a sum of the parts: they assess overall system resilience by measuring component properties using readily quantifiable measurements. However, there are no universally applicable resilience metrics or methods for formally valuing systems by individual components (Linkov and Kott 2019). Furthermore, complex systems have demonstrated that individual components can fulfill objectives while imperiling the overall system operation, as

was the case with the perverse incentives that precipitated the sub-prime mortgage crisis in 2008 (Zhang 2018). Such *emergent properties* of complex systems show a discontinuity between the behavior of the system's parts and the behavior of the system as a whole (Goldstein 1999) and may jeopardize the accuracy of resilience measurements that rely on components rather than the interacting processes underlying overall system functionality.

Model-based approaches take a broader view by examining the system mission, temporal patterns, thresholds, memory, function, and adaptation. This can include simulating the physical impacts of a disruption to measure the process of recovery or examining data on system performance for statistics. Bayesian methods can combine process, statistical models, and network models to present the system as interconnected networks dependent on system functioning. Game theory and agent-based approaches examine system performance within a model using a limited set of rules defined by the modelers (Linkov and Kott 2019).

Although the complexities surrounding the understanding of risk as a concept have successfully been rendered into a universally applicable paradigm, there is currently no analogous framework for resilience. Herein we examine gerontological resilience specifically to propose an assessment tool to enable planners and managers to make better decisions to support their elderly patients and the elderly population.

Definitions of Resilience for Aging and Health

Public health, medicine, and the interdisciplinary field of gerontology each conceptualize resilience in slightly different ways. To narrow the scope of literature reviewed, this section will provide an overview of these disciplines' definitions as applied to resilience management for older adults.

Medicine and Gerontology

Gerontology is the scientific study of old age, the aging process, and the particular problems of old people (gerontology, n." 2019). Gerontology is not exclusive to the field of medicine; it spans multiple disciplines from nursing to sociology. Geriatrics, in contrast, is a branch of medicine that deals with the health and care of older people. We will focus on gerontology and conceptualizations of resilience within the field of medicine and public health, although further applications are possible.

The first explorations of resilience within psychological frameworks studied children and only slowly incorporated other stages of lifespan such as young adult, midlife, and finally the elderly (Fontes and Neri 2015; Hayslip 2012). This trajectory influenced biomedical and pharmaceutical research to include resilience in theories of elderly health and overall well-being during old age (Masten and Reed

2002; Earvolino-Ramirez 2007; Newman 2005; Rutter 1987, 1993). However, resilience is used as a metaphor, and such use has caused abstract discussions of its meaning across medical sub-disciplines (Linkov et al. 2013).

Broadly, medical literature defines aging resilience as anything from persevering in the face of life's chronic misfortunes to a stable trajectory toward healthy functioning after a highly adverse event. Table 1, below, shows medicine and gerontology definitions of resilience and specifies where they deviate from the NAS definition. There is some consistency between the NAS definition for resilience to natural disasters and definitions within medical and public health disciplines. Herein we list common definitions as well as their distinctions from the NAS definition for the purpose of identifying conceptual gaps and synergies and potential adaptive processes. We note that many focus on maintaining stability, contrary to the NAS assumption that resilience manifests when a critical function experiences disruption and needs to recover. Recovery is not frequently mentioned, though adaptation often is.

Table 1 Selected definitions of resilience in medicine and gerontology

Health actor or organization	Resilience definition	Distinction from NAS resilience definition
World Health Organization (Ziglio 2017)	Resilience is the ability to maintain or improve a level of functional ability in the face of adversity (either through resistance, recovery or adaptation)	NAS resilience does not denote maintenance, it assumes a decrease in critical function that will require recovery
American Psychological Association (2019)	The process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress — such as family and relationship problems, serious health problems or workplace and financial stressors. It means "bouncing back" from difficult experiences	NAS stipulates that adaptation happens *after* recovery ("bouncing back")
Mayo Clinic (2020)	Resilience means being able to adapt to life's misfortunes and setbacks	NAS lists adaptation is a stage of resilience after recovery
USAID (2013)	The ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth	Extends beyond NAS resilience definitions by seeking to reduce chronic vulnerability and facilitate inclusive growth
Kruk et al. (2015)	Health system resilience is the capacity of health actors, institutions, and populations to prepare for and effectively respond to crises; maintain core functions when a crisis hits; and, informed by lessons learned during the crisis, reorganize if conditions require it	NAS definitions assumes that core functions will experience some disruption

(continued)

Table 1 (continued)

Health actor or organization	Resilience definition	Distinction from NAS resilience definition
Panter-Brick and Leckman (2013) and Southwick et al. (2014)	Resilience is a process to harness resources to sustain well-being	NAS presumes a dip in well-being
Masten (2014, 2015)	The capacity of a dynamic system to adapt successfully to disturbances that threaten the viability, the function, or the development of that system	NAS resilience requires that disturbances are realized, not threatened
Ager et al. (2013)	Structural resilience is building robust structures in society that provide people with the wherewithal to make a living, secure housing, access good education and health care, and realize their human potential	No mention of disruptions or recovery to them
Southwick et al. (2014)	Resilience is a stable trajectory of healthy functioning after a highly adverse event	Resilience is returning to a stable position after an adverse event that caused a dip in functionality.
Southwick et al. (2014)	Definitions of resilience range from a stable trajectory of healthy functioning after a highly adverse event; a conscious effort to move forward in an insightful and integrated positive manner as a result of lessons learned from an adverse experience; the capacity of a dynamic system to adapt successfully to disturbances that threaten the viability, function, and development of that system; and to a process to harness resources in order to sustain well-being	No mention of recovery, focus on adaptation
Kruk et al. (2017)	Resilience emphasizes the functions health systems need to respond and adapt to health shocks, introducing a dynamic dimension into more static health system models which can help the system cope with surges in demand and adapt to changing epidemiology and population expectations of care	[compatible]
Garmezy et al. (1984)	The concept of resilience is centered on the capacity to 'bounce back' from an adverse event	[compatible]
Wagnild and Collins (2009)	Resilience is the ability to adapt or "bounce back" following adversity and challenge and connotes inner strength, competence, optimism, flexibility, and the ability to cope effectively when faced with adversity	Compatible with NAS, but its focus on individual traits will be discussed later in this chapter
Wister et al. (2018)	[resilience is] the ability and resources needed to adapt and navigate stress-inducing experiences	Adapt and navigate may not imply recovery

Resilience is seen as either a mediator or a moderator in exposure-outcome relationships. The only agreement between researchers using the term is that "no generally accepted definition of resilience" exists (Cosco et al. 2016). Resnick et al. (2018) find that resilience in aging is most commonly conceptualized as a "process or behavioral response that can be strengthened, improved, and called upon to establish, maintain, or regain a state of physical, psychological, or emotional equilibrium over time (Resnick et al. 2018)."

The theories of resilience for aging adults stemmed from development psychology and have enriched existing models of Successful Aging (SA) (Cosco et al. 2018). SA is a concept, approach, model, experience, and outcome heavily debated among medical researchers (Katz and Calasanti 2015; Rowe and Kahn 1987; Smith et al. 2018). It states that while aging, people move along a continuum from robustness and autonomy to frailty and dependence. SA examines the characteristics that influence or help determine an older adult's functional performance in relation to younger adults. Elderly adults who exhibit high SA have shown effective adaptation to challenges throughout their older adult life. Recent scientific literature examines the operationalization of SA, revealing over a hundred different definitions (Cosco et al. 2014, 2017). The lack of a consistent SA definition is a fundamental weakness that has produced a similar weakness in existing research on aging and resilience (Cosco et al. 2014). Many of the models of SA include the following five characteristics: (1) successful aging happens across the lifespan; (2) successful aging occurs in response to challenges; (3) successful aging is defined uniquely for each individual to the degree that individual goals and preferences differ; (4) capacity for successful aging is partially under individual control and partially predetermined; and (5) successful aging incorporates many domains (i.e. health, social, biological, psychological) (Smith et al. 2018).

A primary criticism of the successful aging model is that it assumes that only persons who are free of negative elements in all domains are aging in a positive manner (Cosco et al. 2018; Smith et al. 2018). It focuses on the prevention of age-related function declines instead of a strength-based optimization of individual, social, and environmental resources (Cosco et al. 2017). Yet, many older people face aging-related challenges. Resilience models of aging offer improvements over SA in their ability to incorporate adversity (Cosco et al. 2018). Resilient aging has been recently conceptualized as the "minimization of negative outcomes and maximization of positive physical and psychological health outcomes in late life (Smith et al. 2018)." Resilience applied to gerontology thus does not stem from resilience theory applications in other fields, but from reactions to existing aging paradigms.

Scholars across gerontology sub-disciplines conceptualize resilience into one of the following categories (1) a trait, (2) a phenotype or observable manifestation of underlying characteristics, (3) a capacity (i.e. outcome derived from such characteristic or capacity), or (4) a trajectory or process (Whitson et al. 2016). In reviewing the definitions of Table 2, we add the category of ability. Resilience as a personality trait is typically defined as a constant and stable resource that enables an individual to respond to stress in a flexible manner (i.e. psychological hardiness) (Fontes and Neri 2015). Within the greater theory of lifespan development, resilience is also

Table 2 Types of resilience in medical literature and their limitations

Domain	Definition	Distinction from NAS definition
Physical (or physiological) Resilience (Resnick et al. 2011)	The ability to recover or optimize function in the face of age-related losses or disease	Age-related losses may denote slow decline rather than punctuated disruptions and recovery
Psychological Resilience (Resnick 2014; Resnick et al. 2011)	An individual's capacity to overcome challenges and avoid decompensation, depression, apathy, and other types of negative psychological outcomes	Stresses avoidance of negative outcomes, rather than the act of recovery
Emotional Resilience (Resnick 2014; Resnick et al. 2011)	The ability to maintain the separation between positive and negative emotions in times of stress	It is not clear how separating emotions relates to recovery from challenges "Times of stress" may not be the same as a challenge that negatively impacts function
Cognitive Resilience (Resnick 2014; Resnick et al. 2011)	An older adult's ability to overcome noted changes in his or her cognitive ability, negative comments he or she may hear from others, and associated stress related to cognitive performance and embarrassment	Nothing about restoring lost abilities, only coping with people observing the loss
Health Resilience (Resnick 2014; Resnick et al. 2011)	The capacity to maintain good health in the face of significant adversity	Maintaining health is not the same as losing some function and recovering Could be considered "robustness" rather than resilience
Community Resilience (Chandra et al. 2011)	…entails the ongoing and developing capacity of the community to account for its vulnerabilities and develop capabilities that aid that community in: (1) Preventing, withstanding, and mitigating the stress of a health incident (2) Recovering in a way that restores the community to a state of self-sufficiency and at least the same level of health and social functioning after a health incident (3) Using knowledge from a past response to strengthen the community's ability to withstand the next health incident	(1) includes prevention, which is risk management, not resilience

(continued)

Table 2 (continued)

Domain	Definition	Distinction from NAS definition
Creative resilience (Metzl and Morrell 2008)	The human ability to think in a less linear, more elastic fashion that helps them overcome adversity	Unclear if creativity is the methodology behind this resilience, or the function being protected by resilience
Spiritual resilience (Manning et al. 2019)	The ability to sustain an individual's sense of self and purpose through a set of beliefs, principles or values	No mention of adversity Sustainability of sense of self and purposes is not recovery after a loss
Motivational resilience (Hardy et al. 2004)	The ability to sustain an individual's characteristics that drives the individual to learn, grow and adapt to their environment	No mention of adversity Sustaining individual's drive to learn, grow, and adapt, is not the same as restoring drive after a loss

conceived as a trajectory that maintains normal development through individual plasticity and the potential for personal change through flexibility and capacity, stemming from prior experiences of risk, trauma, limitations, and losses suffered throughout life (Fontes and Neri 2015). A resilient life trajectory can emerge when an individual experiences adversity, has or develops protective factors, and ultimately attains a positive health outcome (Hayslip 2012). Lastly, gerontology associates resilience with key characteristics or capacities of adaptation such as psychological coping, social coping, social learning, and emotional regulation. Often, *theories of reserve* view resilience as a capacity or characteristic that is accrued over time to be used in moments of hardship (i.e. common in the case of cognitive reserve and Alzheimer's prevention) (Cosco et al. 2017; Stern 2007). For example, individual, social, and environmental resources are seen as areas in which individuals can build reserves to foster resilience against adversity, though this may equate resilience with reduced vulnerability, which are distinct according to the NAS definition.

Three components are common to almost all conceptualizations of resilience when using a life span perspective. The first is that an individual faces some form of adversity. The second is that the individual has a positive response, sometimes referred to as adaptation, to adversity (Cosco et al. 2016). The third is that most of these definitions perceive the goal of resilience to be adaptation against the increasing adversity that comes with normal aging (Cosco et al. 2018). This adaptation may refer to establishing a new optimal operation of a critical function, or to resisting the same pathway of downward degradation experienced by others in similar positions. Ultimately, degradation to a state of death remains inevitable, so resilience cannot be permanent, but is measured relative to others such that an individual can be deemed more or less resilient than someone else (Fig. 5).

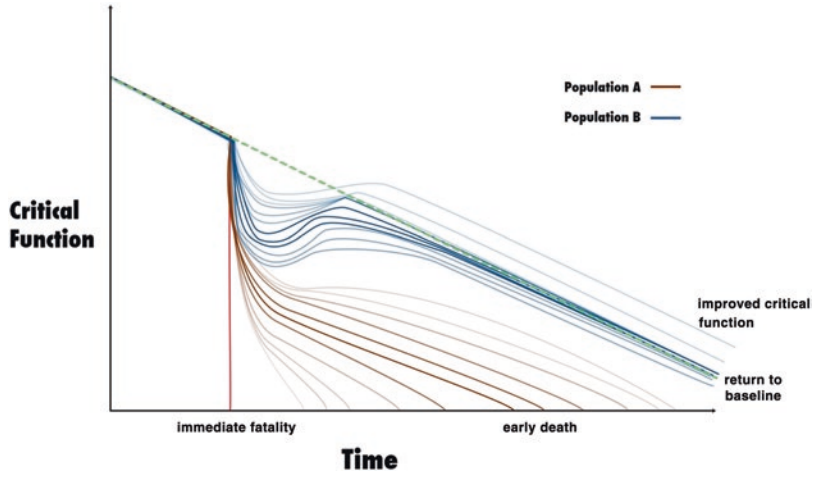

Fig. 5 Resilience between populations

While not all studies on aging incorporate resilience, most highlight the importance of mental health and cognitive function towards the process of adaptation after an adverse event. Elderly individuals face many risks, and practitioners and scholars agree that protections against these risks are important to ensure positive health outcomes. However, scholars disagree on what constitutes a risk, whether an individual needs to experience risks or adversity to develop resilience, and how positive outcomes are defined for aging resilience (Hayslip 2012). For example, a lack of disease or disorder, or above normal outcomes despite difficult circumstances, are limited approaches to understanding resilience, but there is little consensus on what it means to be a "healthy" older adult. Positive outcomes do not always easily generalize across time or domains because outcomes are dependent upon the measures used to determine them. Furthermore, resilience is often viewed separately from recovery in the medical field (Hayslip 2012).

Resilience is a multi-dimensional concept with an unlimited number of interacting variables. Thus, resilience in the medical field is divided into specific domains such as physical, psychological, emotional, cognitive, health, motivational, community, spiritual, and creative resilience (see Table 2). However, these divisions can continue indefinitely, leading to a dilution of resilience meaning and theory-making and more fragmentation across health fields. Breadth and specificity must be balanced because the current lack of consensus on how to operationalize resilience has led to weak linkages between concepts and methods that is further confused by discipline-specific technical language. Therefore, resilience across health fields has encountered the same two obstacles that have inhibited resilience measurement in other complex systems: (1) resilience is often conflated with risk analysis and quantitative risk assessment, and (2) resilience knowledge is fragmented across separate disciplines that do not typically communicate with one another (Hayslip 2012).

While consensus over a common definition for resilience may never be reached across all health fields, researchers and practitioners agree on its importance to gerontology. Therefore, a standard model or framework may be useful in order to better understand and measure resilience for aging older adults.

Table 2 provides definitions of resilience for specific domains in medical literature and their distinctions from the NAS definition for disaster resilience.

Public Health and Aging

Resilience is salient for the public health domain as more of the population lives longer and the role of public health in ensuring well-being among older individuals continues to grow. The WHO has observed the mounting burden of aging on health systems around the world (World Health Organization 2002, 2015, 2017). Many supranational and national public health roadmaps focus on the prevention of frailty among the elderly, especially as it pertains to physical and cognitive decline (Road Map for State and Local Public Health 2020; Galea and Huber 2012). Frailty in public health is not a disease, but a syndrome of extreme vulnerability to life stressors and adversities, typically involving impairments and imbalances to physiological functional systems, such as lung capacity, leg strength, and diminished energy reserve (Cesari et al. 2016). The pace of population aging, coupled with increasing rates of some aging-related adversities, such as multimorbidity, means that the population health burden is growing at unprecedented rates. To ensure successful and active aging processes, many public health organizations and policies focus on preventing frailty among the elderly to avoid the cascading negative consequences of disease and disability at old age.

Policy responses to aging are often developed in siloes and thus disjointed, reflecting broader public polarization of perceptions of old age. At one extreme, old age is viewed as an apocalyptic crisis of immense vulnerability, disengagement, and dependency, leading to a "care of the elderly" perspective. At the other extreme, old age is conceived as an important period of social engagement in which the elderly contribute to all levels of society (e.g. capital generation, volunteerism, and intergenerational support), outweighing social costs with the benefits that they contribute. Neither perspective is wrong, but neither is entirely correct. Effective public health policy for aging requires a compromise between the two views.

Medical conceptualizations of resilience primarily emerged from the SA model, whereas public health often references "active aging" in its frameworks and policies. Active aging hypothesizes that staying active in later life can help maintain overall health and well-being (Havighurst 1961; Rantanen et al. 2018). Active aging is considered a distinct process from SA because an individual strives to reach or maintain elements of well-being through activities relating to that person's goals, functional capacities, and opportunities (Rantanen et al. 2019). Active aging also includes compensating for functional limitations with environmental and social support (Foster and Walker 2015). Typically, the active versus successful aging

divide is seen in European and United States policy discourse, respectively (Rowe and Kahn 1987; Foster and Walker 2015).

In 2002, the World Health Organization (WHO) adopted active aging as its underlying policy goal for elderly health, defining the concept as the process of optimizing opportunities for health, participation, and security in order to enhance quality of life into old age (World Health Organization 2002). The WHO acts as a public health authority, but its influence transcends into the clinical and medical spheres. However, in 2015, in its *World Report on Ageing and Health*, the WHO pivoted towards a more inclusive approach towards active aging policy called healthy aging (see Fig. 6). Healthy aging is defined as "the process of developing and maintaining the functional ability that enables well-being in older age (World Health Organization 2015)." The WHO concept of healthy aging considers an individual as a product of their intrinsic capacity (i.e. personal characteristics, genetic inheritance, and health characteristics), extrinsic environmental characteristics, and functional ability (i.e. intrinsic capacity, extrinsic environmental characteristics and their interactions). Stemming from *theories of reserve*, the model of healthy aging

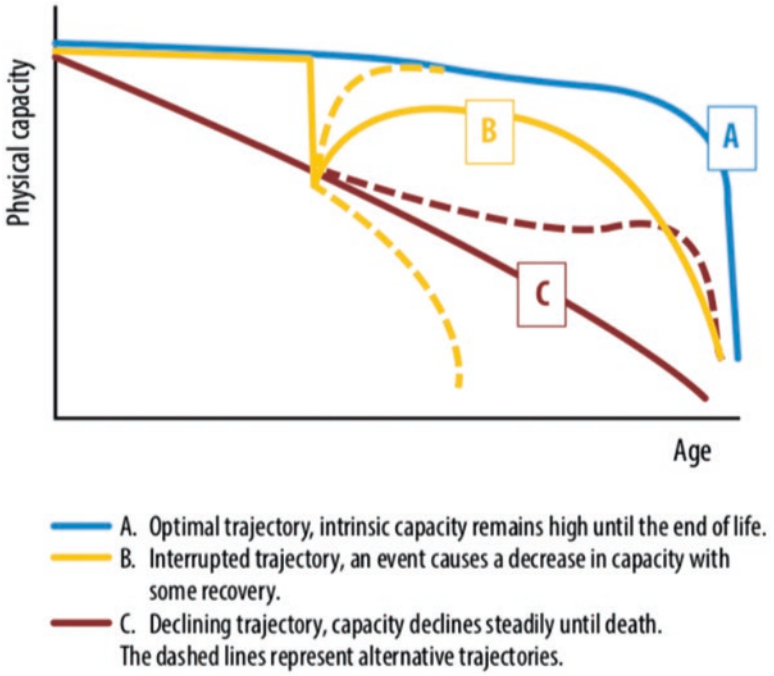

Fig. 6 Various trajectories of physical capacity over time. (**a**) is the optimal trajectory where the individual has a high intrinsic capacity until the end of life. (**b**) shows an individual that experiences different disruptions. They have different options as to how they can recover. (**c**) is a declining trajectory where capacity continuously declines until death. From the World Health Organization. World report on ageing and health. World Health Organization, 2015

assumes that an individual accumulates reserves of functional ability throughout life that contribute to fostering resilience at older ages (World Health Organization 2015). Here, resilience is "the ability to maintain or improve a level of functional ability in the face of adversity" (either through resistance, recovery or adaptation). While the definition used by the WHO stems from medical and gerontological literature, it still applies to the broader public health sphere. The WHO must balance both systems-level public health policies and individual level healthcare outcomes. Resilience comprises both intrinsic capacity (i.e. psychological traits) and environmental attributes (i.e. social networks and access to healthcare). Unlike traditional medical literature, the WHO applies this definition to population health.

In the public health framework, aging is positioned on a trajectory where physical capacity slowly declines, as one grows older. Healthy aging divides this trajectory into three periods (see Fig. 6) that are not defined by age and are not monotonic (World Health Organization 2015). The first is a period of high and stable physical capacity. The second is a period of declining physical capacity. The third is a period of significant loss of physical capacity (World Health Organization 2015).

This life course perspective reinforces the preventative nature of active aging. System shocks can precipitate regime changes (Connelly et al. 2017) and thresholds determine a system's ability to absorb a shock (Connelly et al. 2017). Defining threshold values that reflect transitions from one state to another (i.e. robustness, frailty, etc.) can help better inform decision-making as to which interventions in gerontology and geriatrics should be implemented and at what point in the trajectory for maximum efficacy and effectiveness.

Resilience occurs when an individual is able to maintain high and stable functional ability and intrinsic capacity over their lifetime for as long as possible (Smith et al. 2018; Foster and Walker 2015; Walker and Foster 2013). This differs from the NAS definition because it is not event-based, but views the entire process of aging as a continuous and relentless adversity to be managed.

The public health system can help provide resources and services during each of these three phases, which further ensures individual and health system resilience. For example, during a period of high and stable capacity, health services should focus on preventing chronic conditions and prioritizing early detection and control of such diseases. The environment (i.e. built environment, social support networks, food system, etc.) should promote capacity-enhancing behaviors. During a period of declining capacity, the health system should transition towards a focus on reversing or slowing an older person's decline in individual capacity, such as through improved formal and self-care/maintenance. Policies focusing on the environment should begin to remove barriers to participation that come with loss of function ability (i.e. age-friendly approaches), while concurrently providing avenues for compensating for such loss (i.e. wheelchair accessibility, aging in place, affordable housing, public transportation), some of which cross domains. Once there is a significant loss of capacity, long-term care services should be available, accessible, and usable. These services can support capacity-enhancing behaviors and begin the process of ensuring a dignified later life and ultimately a "good" death (Smith et al. 2018; Foster and Walker 2015; Walker and Foster 2013).

Quantifying Resilience for the Elderly

Resilience Quantification in Medicine and Public Health

The WHO emphasizes that new knowledge on aging and health is critical to useful and impactful clinical practice, population health intervention, and social policies (World Health Organization 2015). Using a resilience framework to understand healthy and successful aging among older adults may help identify protective factors associated with resilience and provide generalizable solutions to the elderly seeking to overcome adversity across their life. Currently, the metrics which are used by researchers do not always align with what individual patients prioritize when adapting to a disruption in health (i.e. biomarkers and objective measures versus psychosocial factors and subjective measures) (Cosco et al. 2013, 2017). There is a need to better understand the specific health needs of older adults as a population and what a healthy trajectory looks like in the face of inevitable disease and physiological or mental decline (Cosco et al. 2013).

Many researchers in health fields conceptualize aging as a linear process (i.e. latent variable modeling and GMM) (Cosco et al. 2016, 2017a, b, 2019; Wister et al. 2018). While linear trends are useful for statistical analyses, aging is a complex, non-linear process. Likewise, the majority of resilience research on aging is conducted in cross-sectional studies (Cosco et al. 2017). Very few longitudinal studies of resilience among the elderly exist despite providing greater insights into resilience across the lifespan. Moreover, benchmarks and thresholds are not consistent across studies. Better metrics are needed in order to use new methodological approaches that can assess and model a complex system.

There is no gold standard to measure or quantify resilience in aging, and studies are highly variable in definitions, measures, and designs. Clinical scholars have examined biomarkers, such as musculoskeletal changes (adiposity, muscle mass, grip strength, bone mineral density, body weight, gait velocity), stem cell changes (% COP, COP lamin A), serum markers (hemoglobin, albumin, oxidation products, antioxidants), metabolic markers (HbA1C), hormonal changes (DHEA, testosterone, Vitamin D, PTH, IGF1), and new inflammatory markers (CRP, IL6, TNFa) (Al Saedi et al. 2019), where high levels denote individual health and latitude to temporarily decrease without immediate negative consequences. Other studies have inferred resilience through examining behaviors and subjective measurements such as emergency department visits, overnight hospital stats, and perceived pain (Wister et al. 2018), which also measure general health rather than ability to absorb and recover from emerging disruptions.

Different contexts produce inequities between the recovery capabilities of different populations of aged adults. Quantifying resilience for the elderly will indicate which sub-populations have a better ability to recover from disruptions, and which populations merit either strengthened protection against disruptions or stronger support should disruptions occur. It can also help planners manage disruptions as they occur in ways productive for long-term recovery, as well as make informed resilience-focused investment decisions during times without disruptions.

Social scientists incorporate social determinants of health by using socio-economic data, social support, and other domains. Self-reported data and surveys are common tools used to collect resilience-specific data. However, the sample sizes in such studies tend to be small and the surveys are not always the same, varying in questions asked and outcomes assessed. More recently, epigenetics and genetic research has provided novel and objective indicators of resilience in health across an individual's lifespan and past generational experiences. External factors, such as poverty, societal perceptions of race, education, and the physical environment, can influence the health outcomes of a single individual. These external factors play a larger role as time passes, meaning that they are of critical importance to the elderly.

Public health suggests that understanding the resilience necessary for different individuals to function at the same level may require first understanding the distinct context in which they live. While health promotion and medicine are often criticized for ignoring these contextual forces, a recent shift has started to view health within the larger framework of the socio-ecological model (Fig. 7), which recognizes that individuals are nested within larger ecosystems that are largely beyond their control.

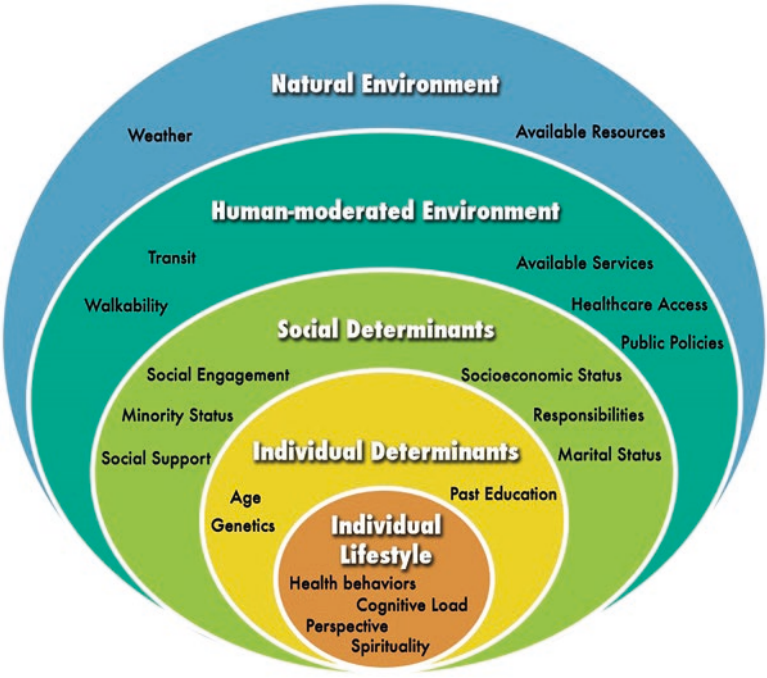

Fig. 7 Socio-ecological model in health. *Adapted from McLeroy, K. R., Steckler, A. and Bibeau, D. (Eds.) (1988). The social ecology of health promotion interventions. Health Education Quarterly, 15(4):351–377*

Within the socio-ecological framework, five spheres influence an individual's well-being, starting with characteristics of an individual, then expanding outwards to the larger environment. Applied to older adults, the first sphere embodies individual healthy behaviors like social engagement and cognitive load. Next, the second sphere includes individual determinants include factors that may be outside the individual's direct control, such as genetics, past education, and socio-economic status that can affect how people experience stressful events (Wister et al. 2016). In the social realm, social cohesion and belonging benefit aging adults (Cramm and Nieboer 2015). Overlaid on the individual and community is the built environment that aging adults live in, including aspects that support the nested systems, like electricity and walkability to grocery stores with fresh produce for healthy meals. Finally, the built environment is subjected to the changes in circumstances or resources of the natural world.

These spheres directly impact numerous factors that determine health behaviors and outcomes, such as institutional factors, community factors, public policy (i.e. governance and law making), intrapersonal factors, and interpersonal processes (Cramm and Nieboer 2015; McLeroy et al. 1988), and can be used to frame quantifications of individual resilience. For example, recent public health "aging-in-place" efforts have attempted to use a broader systems perspective to support the long term resilience of the elderly by using a socio-ecological perspective (Acosta et al. 2018). The socio-ecological model uses a complex systems perspective and provides a framework for organizing common features of health applicable to aging.

Importantly, the nesting of the spheres provides a helpful framework for understanding risks and their disruptions to various spheres and their relationship to individuals. Aggregating these factors together could provide a risk quantification for a specific profile of an aging person (i.e. a Hispanic parishioner living in a flood zone), but the manifestation of the risk and subsequent resilience capabilities needed may depend on which sphere it strikes. A disruption of the social environment, such as the closing of a café that serves as a gathering place for retired adults, will impact only the nested health determinants and will not be mitigated by disaster insurance. Meanwhile, the impact of a disruption to the natural environment, like a tornado or a pandemic such as COVID-19, could disrupt all systems. Resilience measures for individuals may benefit by incorporating these different contexts.

Resilience Matrix for the Elderly

We can begin to quantify different aspects of elderly resilience through the resilience matrix (Linkov et al. 2013). The resilience matrix (Fig. 8) combines the National Academies of Sciences system functions (plan/prepare, absorb, recover, adapt) and Network-Centric Warfare domains, an established paradigm that collects data in the physical realm, and translates it to information to be used for cognitive decision making (Alberts et al. 2001). These three domains are confined to the first two spheres of the socio-ecological framework. A fourth domain, social, is overlaid

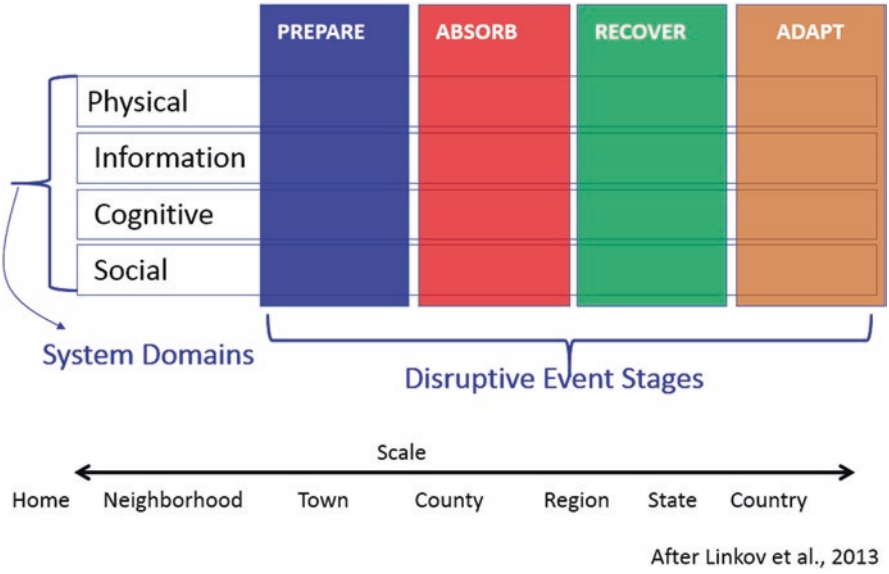

Fig. 8 Resilience matrix for natural disasters

on them, correlating to the social sphere which incorporates some outside influences, such as reciprocity in social relationships. Thus, the Network-Centric Warfare domains almost entirely concern the individual's agency in his or her resilience.

Metrics are constructed using existing gerontology research and by assessing their implications throughout the different stages and domains as they apply to a geriatric population. Each cell in the matrix addresses the question: "How is the system's ability to [plan/prepare for, absorb, recover from, adapt to] a health disruption among older individuals implemented in the [physical, information, cognitive, social] domain?" Since many metrics are difficult to measure through direct means, they must be estimated using a system-by-system basis that incorporates both quantitative and qualitative measures.

The physical responses characterize the circumstances of an individual's body. Informational responses encompass the information and resources available to individuals to help them cope during disruptions, and cognitive responses reflect the individual's engagement with the changes needed during disruptions. The social responses encompass the existing structure of the individual's social network and specifically its ability or willingness to support an individual, including when the individual might not be actively engaged in seeking support. The four domains all contribute to an individual's ability to prepare for, absorb, recover from, and adapt to disruptions (Table 3).

Table 3 Resilience matrix populated to quantify resilience for older adults

	Prepare	Absorb	Recover	Adapt
Physical	Good state of health	Functioning systems available to respond	System works to restore lost function	Optimal value of lost function attained or improved upon
Metric	*Blood pressure, mobility, grip strength,* etc.	*Immune system, other body attributes*	*Is recovery occurring, are system attributes improving?*	*Blood pressure, mobility, grip strength,* etc.
Informational	Registered for relevant services and alerts	Identify problems, engage with appropriate agencies to resolve	Use the resources for needed support	Resource management
Metric	*Number and relevance of services signed up for*	*Does individual confront and address problems?*	*Output of resources (money, assistance)*	*Do the resources meet the need over time?*
Cognitive	Awareness of baseline health and needs	Recognize new challenges and seek information and recommendations	Decision-making and behavioral change to respond to new circumstances	Sustained behavioral changes
Metrics	*Is individual aware of events? Does individual know baseline expectations for health?*	*Does individual recognize and act on emerging problems?*	*What behavior changes are committed to adjust to new circumstances?*	*Are the adaptive changes maintained over time?*
Social	Many groups of friends and acquaintances	Social ties engage to ensure individual is reacting to disruption	Social ties provide resources and support	Social ties are retained despite new circumstances
Metric	*How many people does individual speak to in a week?*	*How many people contact individual in a week?*	*How many contacts have resources to give support?*	*Percentage of ties independent of a specific context*

The resilience matrix can characterize an individual within diverse contexts. However, as seen in the socio-ecological framework, many factors influencing well-being are beyond individual control. The outmost spheres of the socio-economic framework can contribute to individual recovery by reducing the burden of the individual resilience. A neighborhood with walkable streets is more conducive to elderly socializing. Although resilience may be measured using an individual scale, the externalities of the socio-ecological model reveal opportunities to further enhance and anchor individual resilience.

From Metrics to Model

Quantifying the individual metrics may not characterize how they will interact for individuals who rate high in some metrics but low in others. Herein we explore some of the complexities of the socio-ecological model of nested spheres as applied to individual resilience.

The medical establishment is concerned with the choices of individuals, and can play a role devising methods to measure such metrics and develop recommendations for improving them among aging adults who score poorly. But informational preparation supposes that resources are available to provide recovery support, something that is largely outside an older adult's control. While access to relevant information is increasingly open in the age of the Internet, it still presents ample barriers for many, especially when a professional is needed to apply the information, such as a doctor or a psychologist. Of more concern, however, is the availability of resources. As risk and vulnerability factors increase, the ability to rely on individual resources decreases, and social or environmental support becomes more important (Ungar 2011). Many elderly adults may know exactly what they need, but may not be able to afford or access services or programs. The role of economic wealth in individual resilience must not be overstated, nor should the political support of health and social service provisions targeting aging populations. Thus, public health inquiries into gerontological resilience are rightly focused on broad-scale interventions. The different managers of individual and public health (health care providers, family caretakers, public health policy writers) all oversee aspects of resilience, which together complement a resilient model.

There is also an important temporal aspect to resilience manifestation. The flexibility that enables rapid responses through social support arises because those supports are not structural, and hence maintaining them long-term may be beyond the social network capacity (Cohen and Syme 1985). In studies of resilience to multimorbidity in the elderly, the time during which support is available matters, given more and less treatable points in illness trajectories. The spheres of the socio-ecological model show varying amounts of temporal volatility. Some individual determinants, such as the role of genetics in affecting illness outcomes, will not change, except in the more extreme cases of epigenetics. Social and physical spheres will be particularly dynamic as individuals age, but the environmental infrastructure, including public policy, will change much more slowly. This creates a structural lag (Riley et al. 1994). Thus, the timing of an individual's resilient response may depend partially on the balance of metrics within his or her specific context, and for this reason a model of interacting metrics may constitute the next step in quantifying resilience.

Conclusion

This chapter retrofits and applies the NAS definition and complex systems model of resilience developed to understand the effects of natural disasters to the quantification of resilience in the elderly, with particular focus on ability to recover from age-related disruptions. This contrasts with existing notions of resilience in gerontology literature, which emerged as a response to the inability of the successful aging paradigm to incorporate adverse events and crucial adaptive processes. Though called resilience in the gerontology literature, the current paradigm focuses strongly on adaptation and coping rather than recovery, particularly given the chronic nature of multimorbidity in older age (Wister et al. 2018).

Resilience in older adults should not be conflated with their pre-existing health status except in quantifying their ability to fully absorb a threat without system failure. There are distinct metrics of resilience for medicine and public health as they relate to gerontology, but models of resilience, specifically applied to aging population or sub-population, should include both because they are irrevocably intertwined. To optimize their capacities over their lifespan, an older individual needs to prepare and respond according to the resilience matrix, but they also require access to, and the ability to harness an umbrella of resources, such as healthcare services, safety, social support, and adequate education (Hayslip 2012). This broad base of needs, reflected in the gerontology literature, corresponds to the various types of disruptions that can influence the spheres of the socio-ecological model, as well as the categorical responses of the resilience matrix. Resilience requires the participation of the individual as well as his or her broader community; thus, it is useful to begin to view resilience as a property of an overall system (Linkov et al. 2014). Resilience is not solely an individual attribute, but inherently tied to the broader context, including economic circumstances, positive social networks, and relationships that may or may relate to individual behavior, as well as the political supports and context made available to people lacking either economic security or long term social support. To lay the responsibility of resilience on an individual alone would remove the larger institutional contexts that also shape an individual's health, as well as their access to resources necessary during recovery.

The emergence of the SARS-CoV-2 novel coronavirus (COVID-19) in the U.S. in early 2020 has revealed an unprepared system with respect to many areas, including testing, ventilators, and other specialized equipment for respiratory diseases: designated intensive care units, etc. This emphasized the importance of the integration of systems as a primary component of response to disasters such as the COVID-19 pandemic that placed older adults and other vulnerable groups at increased risk of morbidity and mortality, especially in the long-term care system. In addition, a resilience approach to the support of seniors may be instrumental in preventing older adults from flooding into hospitals and overburdening the overall healthcare system.

While resilience analysis cannot replace risk assessment, it can provide a systems approach to complex processes that have multiple nested domains, emergent properties, and potential underlying processes. A resilience management framework

includes risk analysis as a key component of its approach, providing a way to plan, prepare, absorb, recover, and adapt from a threat that has a high incidence of uncertainty. Rapid and efficient recovery is critical to the resilience of a system. Early integration of resilience into the design of systems such as health, community, and long-term care can help lay the groundwork for resilience thinking.

Aging is an unpredictable process and the human body is a complex system. Establishing a framework for resilience in aging will require specific methods to define and measure resilience. New modeling and simulation techniques for complex systems could be tested and evaluated for their usefulness. Researchers should continue to develop the field of gerontology resilience through collaboration with other disciplines, including systems engineering, public health, computer science, and the bio-sciences. Lastly, there needs to be clear strategies for communication of the importance of resilience approaches to key stakeholders and actors. Resilience management needs to be prioritized in patient health behavior, provider decision-making, clinical guidelines, public health policies, and healthcare infrastructure, not just in scientific research and theory.

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Multimorbidity Resilience: Conceptual, Theoretical, and Measurement Developments

Andrew V. Wister

Abstract This chapter describes the development and application of a theoretical model of multimorbidity resilience, and a measure-multimorbidity resilience index specifically aimed for use in population health surveys. The Lifecourse Model of Multimorbidity Resilience (LMMR) links resources embedded in multi-level domains and elaborates key processes that occur during disruption and reintegration along a life trajectory. It furthers our understanding of resilience processes underlying the outcomes of wellness, recovery, and growth/development among older persons facing multimorbidity. In addition, a multimorbidity resilience index comprising functional, social, and psychological domains capturing both adversity and adaptation is described. The results of criterion validation of the index based on health care utilization and health status outcomes is presented, and offers support for this measure. Further confirmatory research is needed for both the LMMR and the multimorbidity resilience index using other known population health data sets. This relevance of multimorbidity resilience has been increased during the COVID-19 pandemic and beyond. Research is also warranted using different populations and sub-populations as well as clinical settings.

Keywords Resilience · Aging · Multimorbidity · Life-course Model · Measurement

Introduction

Researchers have increasingly addressed the ways in which individuals respond to illness-related adversities to maintain or regain a sense of wellness in their lives, especially over the latter stages of the life-course (Sells et al. 2009; Windle et al. 2010). One predominant and often debilitating health condition experienced with advanced age is *multimorbidity*, which is the co-occurrence of two or more chronic

A. V. Wister (✉)
Department of Gerontology, Simon Fraser University, Vancouver, BC, Canada
e-mail: wister@sfu.ca

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illnesses. In Canada, the United States, Australia, and other developed countries, approximately two-thirds of adults aged 65 and over experience multimorbidity (Islam et al. 2014; Wister et al. 2016a), and these rates rise among the very old. For example, it has been estimated that multimorbidity prevalence rates in the US were 62% among persons aged 65–74, 75.7% aged 75–84, and 81.5% aged 85+ (Salive 2013). The high prevalence of multimorbidity and its often-pathogenic synergistic effects among disease contexts can be particularly stressful among older adults, since they tend to experience a decline in coping ability (Pearlin et al. 2005; Institute of Medicine 2012). Multimorbidity has also been associated with increased utilization and cost of health care resources (Agborsangaya et al. 2013), as well as decreased functional ability and quality of life (Galenkamp et al. 2011; Wister et al. 2019). The recent COVID-19 pandemic has revealed the importance of underlying health conditions for the risk of contracting the disease, as well as morbidity and mortality outcomes.

Given the tendency for chronic conditions to be long lasting, entail pain or discomfort, and limit performance of daily activities and social roles, it is not surprising that the chronic illness and aging literature has focused on pathogenic or disablement processes. However, it has become increasingly apparent that some older adults maintain relatively high functioning and well-being in the face of multimorbidity, what has been labelled 'living well,' 'positive deviance,' "healthy aging paradox", or 'resilience' (Rybarczyk et al. 2012; Sells et al. 2009). Indeed, *resilience* concepts have become a focal point in this work; generally defined as the adaptive ability and resources required to navigate stress-inducing experiences, and/or responding to adversity better than average or expected (see Resnick, chapter "Resilience in Older Adults: What it is and How to Strengthen It"). Positive adaptation or partial recovery of concurrent chronic illnesses is what we term *multimorbidity resilience* (MR) (Wister et al. 2018, 2020a). Two significant gaps in the literature are particularly relevant: (a) the need for a model of MR that specifies the processes embedded in this form of adversity; and (b) the development of measures that can capture the multi-level domains of MR (Cosco et al. 2017a; Pruchno and Carr 2017). This chapter develops a rationale for a life-course model of multimorbidity resilience, followed by a review and development of a multimorbidity resilience index.

Part I: Conceptual and Theoretical Developments in Multimorbidity Resilience

Conceptualizing multimorbidity as a form of adversity requires consideration of episodic and non-linear illness trajectories, and its biopsychosocial causal nexus (Martin 2016; Cosco et al. 2018). It is highly variable in a population, with some degree of intraindividual variability, and certain illnesses tend to cluster (e.g., diabetes and cardiovascular disease). A resilience framework applied to multimorbidity needs to be relevant to this context. We have identified five fundamental axioms of MR. (1) MR should be understood using a dynamic model that can capture the

often-multilayered fluid illness trajectories linked to multimorbidity. (2) MR can be both a potential precursor or moderator to positive adaptation of the symptomology associated with a particular constellation of illnesses, as well as a moderator or mediator between illness conditions and illness management/recovery processes. (3) MR can be conceptualized as the gap between the expected (negative) outcomes of multimorbidity, and the actual lived illness experiences of older adults. (4) MR is an adaptive process through which individual traits, internal and external resources, and characteristics of their environment are utilized in the face of illness adversity. (5) A final fundamental aspect of MR is the potential occurrence of cumulative effects and/or emerging effects that occur along the life course. These axioms encourage the exploration of positive pathways, coping thresholds, and adaptive protective processes, including harnessing multiple types of resources and interventions that foster resilience.

A life-course perspective is well-suited to MR, given that it can link past health and illness experiences with current individual-level (e.g., agency, self-efficacy, cultural capital, past illness experience, and socio-economic resources) and environmental-level contexts (e.g., access and availability of health care services, social support networks, and the built environment). It also acknowledges the agency that individuals can employ to overcome various adversities associated with not only multimorbidity, but also other aging-related challenges. The individual (micro) and structural (macro) processes that occur within and between cohorts, and the intersection of these factors, are central tenants of this theory. Finally, a life-course lens links lives of individuals and, therefore, gives primacy to social network connections and their influence on coping and adaptation in the face of illness.

The development of a life-course model of multimorbidity resilience (LMMR) utilized a comprehensive search of literature. Literature published between 1995 and 2019 was collected, scanned, and analyzed using AgeLine, PsychInfo, and PubMed databases, and the following keywords: resilience, resiliency (or resilien*), chronic illness, chronic condition, comorbid*, multimorbidity, living well, aging, older adult, elder*, lifespan. Two independent researchers identified, extracted and synthesized 162 publications deemed most relevant to resilience with specific applications to chronic illness and multimorbidity. The following themes were identified: (1) how living well and resilience has been defined and quantified within the academic literature; (2) conceptual and theoretical perspectives of resilience that encompass life-course/developmental/aging frameworks, and; (3) how research can inform applications of resilience to older adults living with multimorbidity.

Formative Resilience Theorizing in Gerontology

Resilience concepts can be situated within a family of psychosocial and socio-environmental theoretical models that attempt to understand adaptation to a range of individual and environmental stressors. We summarize several clusters of theories applied to development/aging in order to position our multimorbidity resilience model. According to positive psychology, adaptation and well-being are determined

by the strengths and resources (i.e., individual resilience) of people through the active pursuit of creative and emotionally fulfilling aspects of human behaviour (Emlet et al. 2011; Seligman and Csikszentmihalyi 2000). It therefore places more attention on salutogenesis (pursuit of healthfulness) than pathogenesis (medical model) as an approach to individual and public health (Antonovsky 1996).

Another grouping of theories has addressed the question of how individuals balance gains and losses required for optimal development. One of the starting points was Pearlin et al.'s (1990) development of the classic stress-coping model, which suggests that effective coping (often involving social support) intercedes at various points along the stress process to reinstate balance. Furthermore, the model of assimilative and accommodative coping distinguishes between two types of coping: assimilation, which is the persistent effort to pursue goals through modification of life circumstances, and accommodation, which is the adjustment of goals due to limitations or restrictions (Greve and Staudinger 2006; Leipold and Greve 2009). It is postulated that appraisals of discrepancy between these dual processes activate cognitive and behavioural change. Both assimilation and accommodation were discovered in Jopp and Rott's (2006) study of positive adaptation and valuation of life in which resilient older adults were able to maintain their goal of social connectedness by replacing face-to-face interpersonal contact with telephone contact during functional decline.

Another highly used model to explain adaptation and aging is selection, optimization, and compensation (SOC) (Baltes and Carstenson 1996; Wild et al. 2013). The SOC theory elucidates three dynamic interlocking processes that enable positive adaptation. Selection refers to choosing what to focus on, optimization is the recruitment and application of appropriate resources, and compensation is the use of alternate means to maintain function (Boerner and Jopp 2007). The theory contends that positive adaptation is most likely to occur when individuals select goals that align with or optimize their available resources (Baltes and Carstenson 1996). Wiles et al. (2012) found that the most resilient older adults utilized selective optimization and compensation in their daily activities. Indeed, even in the face of multimorbidity, it was common for the resilient participants to persist with activities that were deemed important in their lives.

Most of the theories presented above have been developed with a focus on the individual. In order to bring in a strong temporal dimension that combines macro-level with micro-level processes, life-course theory has been applied to understanding many aging-related transitions and behaviours. This theory connects structural (i.e., historical, institutional, community and cohort-related) and individual (i.e., social resources and agency) factors in shaping pathways and outcomes of individuals across time (age-period-cohort) (Dannefer et al. 2009; Elder and Johnson 2003; Mitchell 2003; Wister 2005; Wister 2019). Life-course theory contends that: (a) human development entails lifelong processes that are shaped by the timing and intensity of early life experiences, events and transitions (e.g., bouncing back from a health-related childhood traumatic event); (b) individuals employ human agency to influence institutional structures (e.g., the effect of demonstrating for improved access to health care in rural and remote areas); (c) historical events (health care

policy development), the size of the age cohorts to which individuals belong (baby boomers), and the age of exposure to events affect experiences and trajectories (e.g., multimorbidity); and (d) lives are lived interdependently such that we affect and are affected by our social networks (e.g., developing early diabetes can create stressful family environments) (Mitchell 2003, 2018). Outcomes (e.g., multimorbidity resilience) are contingent upon the availability and accessibility of resources or capital (genetics, identity, competence, empowerment, education, wealth, health, social support,) that influence the ability to deal with or adapt to stressful events in life (O'Rand 2006). Applied to multimorbidity resilience, life-course assumptions provide a theoretical rationale for what has been termed a 'resilience trajectory' in older age, that includes the role of past experiences of coping and overcoming illness adversity (Clark et al. 2011; Windle 2012).

This raises the question of whether resilience improves over the life course due to experiential learning (e.g., social learning related to illness experiences and adaptation) or whether resilience naturally declines with age as a function of age-related decline. Some research suggests that resilience actually improves during old age, perhaps through experiential learning and efficacy, although the reasons are not entirely clear (Rybarczyk et al. 2012). Most research contends that resilience erodes with age-related decline (Sells et al. 2009). Although there is a large literature on coping, stress, and health over the life course (Pearlin and Skaff 1996; Pearlin et al. 2005), the increasing prevalence of multimorbidity occurring in old age begs specification of current models. Figure 1 shows the resilience and aging competing hypotheses. These require empirical studies to support or refute these potential patterns.

Another grouping of theories has addressed adaptation and aging from a multilevel socio-environmental perspective. It has been characterized by the balance between an individual's needs and abilities and the demands of the environment (Greve and Staudinger 2006; Lawton 1980). For example, Lawton (1980) postulates that maximization of well-being and positive adaptation occurs when individual competence and environmental demands (physical, social, community) are in balance. It also hypothesizes that people can withstand environmental press more effectively when they are younger versus elderly. This theory emphasizes not only the importance of the environment to successful adaptation, but also the concept of an optimal zone of adaptation, and potential resilience thresholds. Wild et al. (2013) created a socio-environmental model consisting of the following six resilience domains: individual, household, family, neighbourhood, community, and societal resilience. These interdependent spheres of influence represent a comprehensive set of resource pools. Similarly, complex systems models have been used to understand responses to external disruptions to a system in an attempt to maintain homeostasis or reach a state of recovery, whether it be aging-related challenges at an individual or community-level (see –Linkov et al. chapter "Science and Practice of Resilience: Disaster Systems Applications to Aging Model Development"). However, a system approach links individual-level experiences to the broader structural context, including economic circumstances, community, and political support systems.

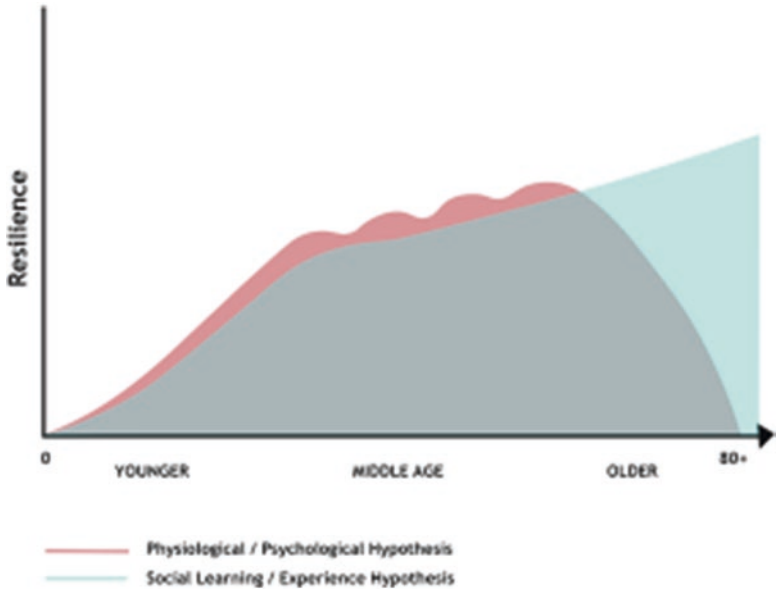

Fig. 1 Competing resilience and aging hypotheses

Focusing a Multimorbidity Resilience Lens

According to the Five Waves of History in Resilience Thinking (Masten 2001, 2007; Wister et al. 2016b), we have reached a period at which point resilience models are being specified to a variety of substantive areas—called the fifth wave of resilience development. Multimorbidity offers a unique opportunity to advance resilience and aging approaches, given that this form of adversity is prevalent, highly variable in the population, episodic over time, and complex in how it is expressed and in its treatment. Capturing this complexity, Sells et al. (2009) conceptualize multimorbidity as contributing to a series of cascading crises in which secondary diagnoses compound other illness challenges. Based on a psychosocial perspective, they provide evidence that the trajectory of multimorbidity often disrupts personal identity such that cascading medical, emotional, and social adversities occur, followed by attempts at adaptation. At a pivotal social level, loss of valued roles, relationships and independence can be rectified by giving and receiving of social support, which in turn can lead to positive adaptation.

Parallel research emphasizes the way in which chronic illness experiences intersect with one's perception of reality, termed the shifting perspectives model (Paterson 2001). In its early stages, an individual will be absorbed by the sickness, suffering, and loss that accompany their condition until such time that they build an energy reserve and work towards homeostasis and well-being. Rebalancing their self-concept and their identity, and experiencing growth, can be fostered by means of activating emotional, economic, social, cultural, and spiritual resources (Paterson

2001; Rybarczyk et al. 2012; Ungar 2011; Zautra et al. 2010; Wister et al. 2020b). Other researchers articulate these multi-level resilience processes. To this end, Richardson (2002) offers a biopsychospiritual model, in which resilient qualities are obtained through processes of disruptions and reintegration, suggesting that resiliency can be learned. The movement from disruption to homeostasis has four levels of reintegration—two that are positive and two that are negative in outcomes. The highest-level reintegration outcome entails growth, knowledge, self-understanding, and enhanced strength of resilience resources from a prevention perspective (Zautra et al. 2010). A second level response is when individuals reintegrate back to homeostasis, characterized by recovery, healing, and overcoming a negative event. The two negative responses include reintegration with loss (i.e., individuals who give up), and dysfunctional reintegration, in which lack of introspective abilities results in conditions favouring repeated failure. A remaining gap in the model is an absence of details as to *how* resilient reintegration occurs (i.e., process and mechanisms), especially at the socio-environmental or ecological/systems level. There may also be variability in responses associated with differing domains in which disruption occurs (emotion, self-identity, function, leisure, relationships, etc.), (Janssen et al. 2011; Ong et al. 2009). A final area of importance pertains to the need to acknowledge temporal aspects of the disruption-recovery nexus, which are especially important as a person progresses through their chronic disease trajectory coupled with age-related decline.

Based on the strengths of earlier conceptualizations of resilience and applying these to the unique context of multimorbidity experienced in older age, a Lifecourse Model of Multimorbidity Resilience is proposed.

A Lifecourse Model of Multimorbidity Resilience

Building on the work of Richardson (2002) and others, Fig. 2 presents a *Lifecourse Model of Multimorbidity Resilience* (LMMR) as a complex set of risk/protective factors, resources, and processes that occur over the life course of the individual to promote resilience (Wister et al. 2016b). This model attempts to reflect the accumulated literature on the nexus of resilience and multimorbidity. At its essence is the axiom that there are a set of interrelated cyclical processes that are multidimensional and dynamic in nature and result from accumulation of life course experiences that are experienced at the later stages of life.

In the LMMR, the individual is concurrently positioned in social and environmental contexts such that resilience experienced at an individual level is connected to the wider socio-environmental system-level landscape in which individuals interact (Stokols 1992; Connelly et al. 2017). For example, the expression of multimorbidity resilience by an older individual might be molded by such factors as housing type, physical location, living arrangement, and proximity to informal sports, and heath/community services. As shown in the top left corner of Fig. 2, a well-integrated individual is represented by three overlapping circles, and is consistent with

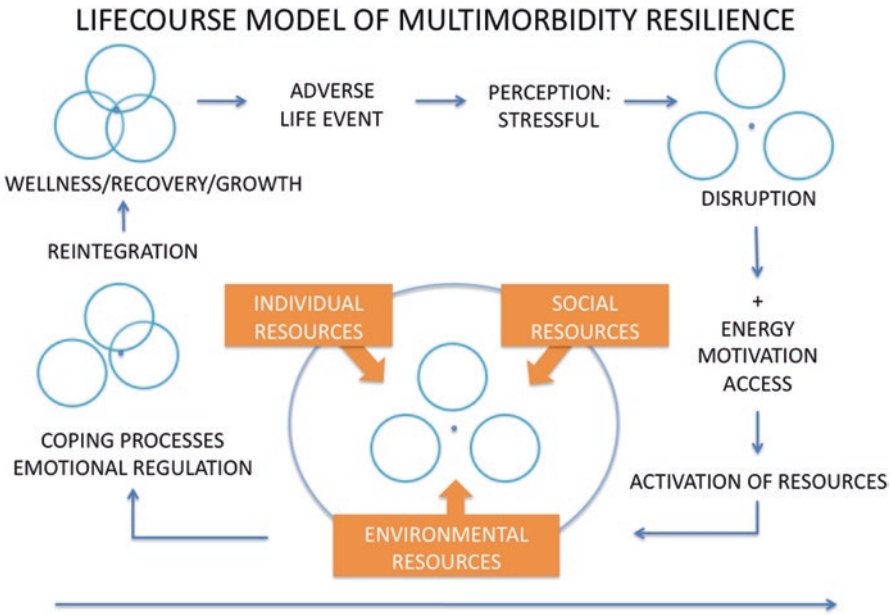

Fig. 2 A life-course model of multimorbidity resilience

Richardson's (2002) biopsychospiritual homeostasis model, and an integrated sense of coherence (Nygren et al. 2005) and wellness (McMahon and Fleury 2012). As such, when one is well, they are able to find purpose and reach potential in their lives, which is a central component of healthy aging. The LMMR captures the cyclical, episodic, non-linear, and fluid nature of the embedded processes. For some, there might be a beginning and ending to achieving an integrated concept of individual well-being in the face of multiple chronic illnesses. Yet, there may also be setbacks, such as the loss of a caregiver who was providing intense social support. Regardless, a common beginning stage in the resilience process applied to multimorbidity (top of Fig. 2) is the onset of adversity (Windle et al. 2010; Windle 2011); for instance, illness adversity tied to the coupling of concurrent symptoms of heart disease and diabetes. The appraisal of stressfulness and challenges that an individual might face due to episodic pain and disability can lead to the disruption of self-concept, attitudes, and behaviours. The fragmentation of self-concept and behavioural routine linked to multimorbidity symptoms (Kralik et al. 2006) is represented in the LMMR by the three disconnected circles in the upper right corner.

A core phase of the resilience process is the accessing and activation of resources, which require motivation, energy, and access (Clark et al. 2011; Richardson 2002; Sells et al. 2009; Wister et al. 2016b). Internal activation of resources is an expression of life-course agency and efficacy (Heckhausen and Schluz 1995), whereas external activation of resources includes tapping into support systems at the social (family), cultural (ethnic community), physical (assistive devices), or structural

(continuing care) level. These are positioned in the center of the model, using Venn diagrammatic form. Mobilization of resources for multimorbidity resilience is dependent on their presence, availability, accessibility, and strength, as well as the inherent ability of an individual to tap into them.

Furthermore, risk and vulnerability may delay resilient outcomes due to deleterious exposures (Harris 2008). Specifically, risk factors include a range of known epidemiological influences on chronic illness, some of which are mutable (physical activity, obesity, pain), and some of which are not (genetics, race). There is an inverse relationship between risk/vulnerability and resources in the LMMR. As risk and vulnerability increase, the ability to rely on individual resources decreases, and therefore, the salience of socio-environmental supports become exemplified (Ungar 2011).

Adaptation and coping with multimorbidity is dependent on activation of resources (on the right side of the model) and emotional regulation (on the left side of the model) that ultimately promote reintegration of a sense of self and foster multimorbidity resilience. Examples of coping include assimilative and accommodative processes of adult development, and selection, optimization, and compensation (Richardson 2002; Stewart and Yuen 2011). The synergies of resources and adaptive processes move the individual towards wellness, recovery, efficacy, balance, growth, and personal development, albeit this is likely incremental or staged. Moreover, the reintegrated self can develop stronger resilience once the processes become internalized and repeated, that is, learned. This is relevant to multimorbidity research, since an individual may not recover, but may learn to function better (positive adaptation) with the concurrent illnesses as a result of resilience (Richardson 2002; Stewart and Yuen 2011).

The temporal dimension of the model is represented by a life-course time line along the bottom of the figure, representing the dynamic, temporal nature of resilience processes and trajectories. Examples of important time-varying elements of the life-course perspective include past learned experiences with multimorbidity, cumulative advantage/disadvantage, and human agency that has resulted in positive change. For example, O'Rand and Hamil-Luker (2005) discovered that early childhood socio-economic and environmental disadvantages increase the risk of disability and chronic diseases later in life, such as cardiovascular disease. On the side of the figure, coping ability may be enhanced over time when human agency is learned and reinforced such that lessons learned from one experience of adversity may foster the development of crucial coping skills needed for subsequent recovery. This suggests that aging may have experiential benefits that enhance resilience, even though age-related physical and cognitive declines may exist (shown in Fig. 1). Of course, not everyone moves through the cycle of recovery and reintegration to the same degree, since there is potential for stagnation, bidirectionality, or reversing deleterious illness effects and/or resilience processes. Thus, analogous to stage of change perspectives, Sells et al. (2009) contend that an individual may remain at a particular level, such as multimorbidity disruption, or they may reverse from wellness to a stage of partial or complete disruption.

Initial formulation of the LMMR and application has produced empirical support for the model. It has been applied to multimorbidity (Dekhtyar et al. 2019; Heid et al. 2018; Wister et al. 2020a), specific diseases, such as Alzheimer's Disease (Windle, chapter "Resilience in Later life: Responding to Criticisms and Applying New Knowledge to the Experience of Dementia"), caregiving resilience (Lopes da Rosa et al. 2018), healthy aging (Cosco et al. 2017a), as well as several related fields. However, a number of research gaps remain. Some of these include but are not limited to: (1) developing a range of measures; (2) elucidating the processes embedded in resilience, (3) conducting qualitative studies that contextualize meanings and experiences of resilience, (4) producing applications to not only different clusters of multimorbidity conditions, but other forms of adversity or combinations of adversity (e.g., multimorbid frail caregivers), (5) application to different subpopulations (e.g., ethnic or racial groups, LGBTQ, Indigenous groups, etc.), (6) capturing non-linear processes of adaptation over the life course, and (7) examination of research gaps pertaining to applied/intervention research.

Turning specifically to intervention research, several potential areas for examination arise. (1) Identification of critical elements, such as teachable moments or periods of susceptibility to change in relation to episodic illness or other adversity; (2) tailoring interventions to harness individual, social, and environmental resources to enhance resilience; (3) interventions need to consider interactions among resources, including cascading influences such that improving a resource in one area strengthens another resource; (4) prioritizing the impact of resources so that an intervention can be targeted to ensure that an individual has the most relevant resources to facilitate resilience; (5) development of programs and policies that integrate the dynamic and process-oriented aspect of resilience, including both accessing and activating resources and coping and adaptation processes; (6) interventions also need to consider and specify the outcomes of resilience that are targeted, whether wellness, recovery, or growth/development. Taken together, applications of the LMMR to interventions need to establish their clinical significance and effectiveness for diverse groups of older adults.

Part II: Development of a Multimorbidity Resilience Measure

Measures of resilience have been dominated by psychological measures that have been primarily used to study mental health conditions and outcomes among children or among the general population (Cosco et al. 2017b; Stewart and Yuen 2011; Windle 2011). Measures of resilience have been highly variable, depending on their theoretical and/or conceptual roots, methodological construction, and application, and typically are not specifically adapted to an older population with unique multimorbidity illness contexts. Within the multimorbidity literature itself, we have a limited understanding of adaptation, self-care/coping, and healthy aging (Sells et al. 2009; Wister et al. 2016a, 2020a). Thus, there remain significant research gaps, given that resilience measures are primarily psychological in nature (i.e., affective

states), or qualitative, rather than covering measurable content domains based on underlying strengths and vulnerabilities from a multimorbidity and aging lens (Cosco et al. 2017b). This section of the chapter operationalizes multimorbidity resilience as the combination of three domains: functional, social, and psychological resilience, comprising adversity and resilience components, based on the LMMR. We specifically chose a large population health survey, the Canadian Longitudinal Study on Aging, to develop and test this measure, due to its inclusion of commonly used variables that tap into these three domains. The usefulness of this measure is assessed based on analyses of criterion validity using key outcome measures of health care utilization and illness context among a vulnerable population of older individuals with multimorbidity.

Conceptual and Theoretical Roots

We begin with the assumption that some individuals may possess or have access to important social support, economic and psychosocial resources and strengths that may enable them to live well with and adapt to multiple chronic conditions (IOM 2012; Rybarczyk et al. 2012; Sells et al. 2009; Trivedi et al. 2011). While many resilience measures focus on recovery, when applied to multimorbidity resilience, it may be more relevant to focus on adaptation and coping, unless a primary prevention approach is adopted. In this line of thinking, the National Academy of Sciences has recently included adaptation as a central component that incorporates complex system reorganization, responses to stress, and social learning that can affect psychological resilience related to natural disasters (Connelly et al. 2017). These processes may be generically important to consider.

The measurement of resilience has been anchored in a diverse number of conceptual frames, including psychological, emotional, spiritual, physical/functional, economic, cultural, and social or ecological resilience (Resnick et al. 2011; Silverman et al. 2015; Wiles et al. 2012; Windle 2012). The Connor-Davidson Resilience Scale (there are several versions) measures the degree to which individuals perceive that they can overcome stress and adversity in life through a general set of questions (Connor and Davidson 2003). It shares similarities with other resilience measures, such as Brief Resilient Coping Scale (Sinclair and Wallston 2004). Although the Connor-Davidson Resilience Scale has been applied to a wide number of subpopulations, including older adults, it assumes that there is a singular concept of resilience. Yet a single concept of resilience does not adequately reflect the full context of multimorbidity among older people, who are exposed to complex layers of health-related adversity by the very nature of illness conditions. Cosco et al. (2017b) critique several approaches to resilience operationalizations in the broader literature due to typologies based on ad hoc definitions of adversity thresholds and positive or negative responses. They further note that data-driven approaches have tended to use cross-sectional data, although some have used repeated-measure analyses of longitudinal data to identify a continuum of resilience, based on change in

levels of adversity and adaptation (Kok et al. chapter "Quantitative Approaches to Examine Resilience and Aging"). This leaves us with little or no agreed upon approach to measuring resilience in the literature. It is therefore an empirical question as to whether there is one unified resilience measure, or whether a family of measures is needed, given the population under study and the unique type of adversity addressed.

Addressing the specific context of multimorbidity, one potential approach is to combine levels of adversity with levels of positive response or adaptation, along key dimensions that capture the adversity of multimorbidity. This is consistent with the notion that resilience may be present but not activated without the occurrence of challenges. The multimorbidity resilience (MR) measure that we develop attempts to tap into resilience by first identifying a sub-population with exposure to adversity—multimorbid older adults; and second, by combining *both* adversity and adaptation (coping) factors into a multi-domain multimorbidity resilience index.

The LMMR offers an overarching framework and rationale for three resilience domains, each of which contains *both* adversity and adaptation (resilience) components (Wister et al. 2016b) (1) *Functional resilience* is vital to aging well with multimorbidity, since it relates to the ability of an individual to complete tasks of everyday living, social roles, and remain physically active (Resnick et al. 2011; Silverman et al. 2015). For instance, overcoming mobility challenges can offer pathways to active aging. (2) *Social resilience* is equally important, given that a multimorbid individual's maintenance of positive social interaction and community engagement protects against loneliness and social isolation and thus negative adaptation. According to the LMMR, the successful activation of social resilience entails harnessing available resources, especially primary social support networks (Sells et al. 2009; Stewart and Yuen 2011). Activation of social resources may include support from a friend or family member, or the utilization of community capital. Social isolation, on the other hand, is expected to result in low levels of multimorbidity social resilience and integration (Wister et al. 2019). (3) *Psychological resilience* entails the ability to mentally cope with stressors associated with multimorbidity. The degree to which individuals perceive stress in the face of multimorbidity, experience degrees of depression or distress, and maintain psychological well-being represent aspects of this domain (Rybarczyk et al. 2012; Stewart and Yuen 2011). Rooted in stress theory and the cognitive appraisal process (Pearlin et al. 2005), stressors due to episodic pain and disability lead to the disruption of self-concept, health behaviours, and health care decisions. On the other hand, feelings of well-being or satisfaction with life can fortify and foster internal activation of resources that can assist individuals to overcome adversity associated with chronic illness (Rybarczyk et al. 2012).

The CLSA Data

This research utilizes the Comprehensive Cohort of the Baseline Wave of the Canadian Longitudinal Study on Aging (CLSA) dataset. This 20-year panel study of persons aged 45–85, launched in 2010, has been funded primarily by the Canadian Institutes for Health Research (CIHR), Canada's federal granting agency for health research. Data were being collected at baseline, including biological, clinical, psychosocial, and societal information that influence disease, health, and well-being (Raina et al. 2009). Participants were randomly selected and invited to participate from the population aged 45–85 (excluding those living in institutions, full-time military, persons living on federal First Nations reserves and in the three northern territories), resulting in a total sample of 51,338, with 30,097 in the Comprehensive Cohort used for this research. The Comprehensive Cohort is used because it contains several physiological measures needed for the development of the multimorbidity resilience index. Comprehensive participants were randomly selected within age/sex strata from within 25 km of dense population data sites, or within 50 km of data collection sites in areas with a lower population density. The 11 data collection sites for the CLSA are located in Victoria, BC; Vancouver, BC; Surrey, BC; Calgary, AB; Winnipeg, MB; Hamilton, ON; Ottawa, ON; Montreal, QC; Sherbrooke, QC; Halifax, NS; and St. John's, NFLD.

A sub-sample of persons aged 65 and over with two or more chronic illnesses (n = 6771) were used from the Comprehensive Cohort, given our interest in multimorbidity resilience among older persons. Sample weights were used to correct for sampling error by age, gender, and geographic location. The self-reported illnesses included two or more of 27 possible chronic conditions, including: Alzheimer's disease, back problems, bowel incontinence, cancer, cataracts, diabetes, epilepsy, glaucoma, heart attack, heart disease, high blood pressure, irritable bowel syndrome, kidney disease, Parkinson's disease, peripheral vascular disease, lung disease, macular degeneration, multiple sclerosis, osteoarthritis, osteoporosis, migraine headaches, rheumatoid arthritis, stroke, thyroid problem, transient ischemic attack, ulcer, and urinary incontinence. The validity and reliability of all relevant measures in the CLSA questionnaires, as well as references, can be found on the Data Portal of the CLSA web site (www.clsa-elcv.ca).

The Multimorbidity Resilience Index

A multimorbidity resilience index was created based on a composite (additive) index of three sub-indices, representing functional, social, and psychological multimorbidity resilience domains (see Wister et al. 2018 for full details). In order to capture both positive and negative aspects of adversity and resilience among multimorbid older adults, each of the sub-indices comprised three index domain measures.

Given different levels of measurement, a standardized method was used to equalize the effects of each variable.

Functional Resilience Variables

The three functional variables were the Older Americans Resources and Services (OARS) Activities of Daily Living (ADL) Scale (Fillenbaum and Smyer 1981), the OARS Instrumental Activities of Daily Living (IADL) Scale (Fillenbaum and Smyer 1981), as well as the Summary Performance Score of functional ability scale (Guralnik et al. 1994). The OARS ADL Scale consists of seven items (Fillenbaum and Smyer 1981) covering key tasks such as eating and bathing. Each question is measured on a scale from 0 (completely unable) to 2 (completely able). Possible total scores range from 0 to 14, with higher scores indicating greater functional status. Similarly, the 7-item OARS IADL Scale also assesses functional ability (Fillenbaum and Smyer 1981). Scores for the OARS IADL Scale questions also range from 0 to 2 and utilized the same coding scheme as above. These tasks are considered to be instrumental to daily living, such as taking medicine and meal preparation, and reflect positive adaptation. The Summary Performance Score used in this study was calculated including a standing balance measure, a walk time measure, and a timed chair raise measure. Similar to this measurement construction, participants who completed these three tasks were assigned scores per task ranging from 1 to 4, which corresponded to statistical quartiles. Participants who did not complete a task were assigned a 0, with a range of 0–12 (Guralnik et al. 1994). As intended, these lower extremity function tests directly measure physical challenge.

Social Resilience Variables

The three variables in the social domain sub-index included the total Medical Outcomes Study (MOS) Social Support Scale (Sherbourne and Stewart 1991), social participation, and a single item measuring perceived loneliness. The total MOS Social Support instrument includes 19 items (Sherbourne and Stewart 1991) consisting of the social support elements of emotional/informational support, affection support, tangible support, and positive social interaction. Each question ranges from 1 (none of the time) to 5 (all of the time). The scale has a range of 19–95, with higher scores indicating greater levels of social support. Social participation is a categorical measure developed by researchers at the CLSA that asked the frequency of participation in activities with family or friends in the past 12 months. The answers ranged from “once a day”, “at least once a week”, “at least once a month”, “at least once a year”, to “never”. This question was recoded into “at least once a week or more” and “at least once a month or less”. The social support/participation measures are deemed to be significant resources for adaptation to multimorbidity. A

single item loneliness ordinal measure assessed how often a participant felt lonely over the past week. This categorical measure ranged from "all of the time, 5-7 days", "occasionally, 3-4 days", "some of the time, 1-2 days" to "rarely or never, less than 1 day". Loneliness is associated with poor multimorbidity outcomes (Wister et al. 2019).

Psychological Resilience Variables

This sub-index included three variables: the Center for Epidemiological Studies Depression (CES-D) Scale (Radloff 1977), the Kessler Psychological Distress K10 Scale (Kessler et al. 2002), and the Diener Satisfaction with Life Scale (Diener et al. 1985). The CES-D Scale ranges from 0 to 60 and contains 20 questions on specific depression symptoms, such as hopefulness, appetite, and concentration. Each question has possible answers from 0 (rarely or none of the time, less than 1 day) to 3 (most or all of the time, 5–7 days). The Kessler Psychological Distress Scale (Kessler et al. 2002) consists of 10 questions with a total range of 0–30. Answers to questions can range from 0 (never) to 3 (most of the time). The depression and distress measures capture the psychological effects of illness adversity. The Diener Satisfaction with Life Scale (Diener et al. 1985) ranges from 5 to 35, with higher scores indicating greater life satisfaction. Individual questions range from 1 (strongly disagree) to 7 (strongly agree). This measures positive well-being and adaptation to illness (Pearlin et al. 2005; Wister et al. 2016b). There is potential overlap of a few items in the depression and distress scales; however, these were deemed to have minimal effect on the index scores, given the number of items in the scales, and their unique constructs.

The standardization method used addresses different measurement types and skewed distributions of measures. An established and validated mapping system (converting all measures into scores between 0 and 10) was employed using the normalization procedure for creating a frailty index (Searle et al. 2008). This method has also been applied to an index of successful aging (Cosco et al. 2015). As shown in Table 1, ordinal measures were converted by dividing the number of responses into 10 proportionately. Continuous measures (after scale construction) were first converted into quartiles to address skewness, and then scaled to 0, 3.3, 6.7, and 10. Finally, the three sub-index scores representing the three major domains were added together and then divided by 3 to convert them back to the standard range of 0–10. Thus, the total composite multimorbidity resilience index was an additive score of the three sub-index scores, and also converted to scores between 0 and 10 (by dividing by 3) for comparability. Higher scores indicated greater multimorbidity resilience.

The intercorrelations between the three sub-domains and the total resilience index scores are presented in Table 2. Correlations among the three sub-indices are relatively low, ranging between .20 and .46 (the high between social and psychological indices). This suggests that they are measuring different domains of

Table 1 Total resilience scale items, values, and calculation

Item	Survey question	Responses	Value	Score calculation
Summary performance score		Lowest quartile	0	A
		Second lowest quartile	3.3	
		Second highest quartile	6.7	
		Highest quartile	10	
OARS ADL scale		Lowest quartile	0	B
		Remainder	10	
OARS instrumental ADL scale		Lowest quartile	0	C
		Remainder	10	
Functional resilience (FR)		Derived interval scale		(A + B + C)/3 = FR
Satisfaction with life scale		Lowest quartile	0	D
		Second lowest quartile	3.3	
		Second highest quartile	6.7	
		Highest quartile	10	
Center for Epidemiologic Studies Depression Scale		Highest quartile	0	E
		Second highest quartile	3.3	
		Second lowest quartile	6.7	
		Lowest quartile	10	
Kessler psychological distress scale		Highest quartile	0	F
		Second highest quartile	3.3	
		Second lowest quartile	6.7	
		Lowest quartile	10	
Psychological resilience (PR)		Derived interval scale		(D + E + F)/3 = PR
MOS social support Total scale		Lowest quartile	0	G
		Second lowest quartile	3.3	
		Second highest quartile	6.7	
		Highest quartile	10	

(continued)

Table 1 (continued)

Item	Survey question	Responses	Value	Score calculation
Loneliness	How often did you feel lonely in the past week?	All of the time (5–7 days)	0	H
		Occasionally (3–4 days)	3.3	
		Some of the time (1–2 days)	6.7	
		Rarely or never (< 1 day)	10	
Social participation	Frequency of participation in family or friends activities out of the household	Never	0	I
		At least once a year	2.5	
		At least once a month	5.0	
		At least once a week	7.5	
		At least once a day	10	
Social Resilience (SR)		Derived interval scale		(G + H + I)/3 = SR
Total Resilience (TR)		Derived interval scale		(FR + PR + SR)/3 = TR

Table 2 Inter-correlation matrix for multimorbidity resilience indexes, weighted (n = 6771)

	Functional resilience	Psychological resilience	Social resilience	Total resilience
Functional resilience	–	–	–	0.68***
Psychological resilience	0.28***	–	–	0.82***
Social resilience	0.20***	0.46***	–	0.69***

*** p<.001

resilience. The correlations between the total resilience index and the sub-indices are considerably higher, ranging between .68 and .82. This indicates that the total resilience index is associated with the sub-domains, but differentially.

Criterion Outcome Variables

In order to assess criterion validity, we reviewed the broad multimorbidity and aging literature, revealing two primary areas. First, health care utilization was identified as a major outcome criterion factor. Extensive research has demonstrated that multimorbidity results in higher health care utilization, especially among older adults (Agborsangaya et al. 2013; Tinetti et al. 2011). Two measures to assess health care

criterion validity were used: emergency room visits; and hospital stays. These were expected to reveal inverse associations with the resilience indices.

Second, several health variables associated with multimorbidity, including perceived pain, perceived health, and sleep quality. These were selected because they capture elements of the illness context that influence quality of life, and are expected to be associated with multimorbidity resilience. Perception of pain was hypothesized to have an inverse association with resilience, given its well-established deleterious effects on coping (IOM 2012; Trivedi et al. 2011), plus its direct links to resilience concepts (Wiles et al. 2012). One of the most consistent global health measure used as an outcome in a multitude of multimorbidity studies is perceived health (Galenkamp et al. 2011; Wister et al. 2016a). Perceived health has also been examined in a study of physical resilience measurement validation (Resnick et al. 2011). Finally, sleep quality has also been associated with multimorbidity outcomes, and represents an important lifestyle factor predicted by deleterious illness experiences (Segovia et al. 2013). As expected, perceived health and sleep quality are hypothesized to have positive associations with the resilience indices. These five variables were used to assess criterion validity in a multivariate analysis. We also adjusted for several socio-demographic covariates used in multimorbidity research, including age, gender, education level, total household income, marital status, and region in the logistic regression analyses (Islam et al. 2014; Wister et al. 2020a, b). In addition, we analyzed models both with and without number of chronic illnesses being adjusted to observe the effects of multimorbidity exceeding two chronic conditions, since multiple chronic conditions likely exert additional effects on resilience.

Criterion Validity Results

All of the relationships between the total multimorbidity resilience measure and the criterion outcome variables were statistically supported and in the hypothesized direction. While similar associations were replicated for the sub-index domains (functional, social, and psychological), it was found that the most pronounced associations arose for the total resilience measure for all five criterion outcome variables. Unadjusted total resilience was associated with: perceived health (OR = 1.72, CI 1.65–1.80); sleep quality (OR = 1.29, CI 1.26–1.33); perceived pain (OR = 0.74, CI 0.72–0.76); hospital overnight stays (OR = 0.82, CI 0.79–0.85); and emergency department visits (OR = 0.86, CI 0.84–0.89). After adjusting for the six socio-demographic variables, the associations between the total resilience index and the health outcomes were replicated, with only slight differences in ORs. These include: perceived health (OR = 1.82, CI 1.73–1.91); sleep quality (OR = 1.35, CI 1.31–1.39); perceived pain (OR = 0.75, CI 0.73–0.78); hospital overnight stays (OR = 0.82, CI 0.79–0.86); and emergency department visits (OR = 0.87, CI 0.84–0.90).

Even after adjusting for number of chronic conditions, relationships were only slightly attenuated, but remained statistically significant and in the expected direc-

tion: perceived health (OR = 1.68, CI 1.59–1.77); sleep quality (OR = 1.34, CI 1.30–1.38); perceived pain (OR = 0.80, CI 0.77–0.83); hospital overnight stays (OR = 0.87, CI 0.83–0.91); and emergency department visits (OR = 0.90, CI 0.87–0.94). Finally, since multimorbidity conditions vary considerably, supplementary analyses were separately conducted on three clusters of multimorbid conditions (vascular, osteoporosis, mental health). Again, all of the regression analyses replicated the above results.

Although sparse, comparative studies offer additional support for the criterion validity of this measure. In particular, in a study of rheumatoid arthritis, Sinclair and Wallston (2004) established adequate internal consistency (baseline Cronbach's alpha = 0.64; and test-retest reliability =0.71) of the Brief Resilient Coping Scale (BRCS), a 4-item measure of tendencies to cope with stress in an adaptive manner. This study also supported correlations with pain coping behaviours and psychological well-being, consistent with the multimorbidity resilience index. Longitudinal studies of resilience in a general population have also been associated with health care utilization. Using cumulative lifetime adversity, social support, and mastery as measures of resilience among persons aged 50–70, drawn from the US Health and Retirement Survey, the authors supported an inverse association with hospital utilization OR = 0.75, CI 0.64–0.86), and a positive association with self-rated health (OR = 1.49, CI 1.17–1.88), after adjusting for socio-demographic and lifestyle covariates (Ezeamama et al. 2016). These associations are virtually identical (but slightly weaker) to the ones found in our CLSA study using the composite multimorbidity resilience index for overnight hospital admissions (OR = 0.87, CI 0.83–0.91), and perceived health (OR = 1.68, CI 1.59–1.77), after adjusting for all covariates.

Another study of resilience (measured as a stressful event within 5 years, level of stressfulness and level of recovery) analyzed a US sample of 546 non-disabled older adults aged 70+ (Hardy et al. 2004). While reported as non-disabled, 56% of their sample had two or more chronic conditions, making them comparable to the CLSA sample. The researchers found associations between their six-item resilience measure and functional status, depression, and self-rated health (SRH). The findings for SRH are consistent with ours (OR = 1.38, CI 1.01–1.79), after adjusting for socio-demographic and functional measures. In addition, other studies have shown support for associations between resilience and pain, as well as sleep, although not directly comparable to the CLSA sample (Segovia et al. 2013; Wiles et al. 2012). Taken together, review of available studies show that our results of the criterion validity outcome analyses using the total MR index are comparable.

Finally, in a recent study of health behaviours as predictors of our measure of multimorbidity resilience among the same CLSA sub sample used to create the measure, several robust findings were uncovered (Wister et al. 2020a). It was shown that, among older adults with two or more illnesses, as well as the cardiovascular/metabolic and osteo-related illness clusters, a non-obese body mass, being a non-smoker, satisfaction with quality of sleep, having a good appetite, and not skipping meals were statistically associated with MR. For the mental-health cluster, in addi-

tion to the above health behaviours, not smoking and inactivity demonstrated moderate positive associations with MR. These findings suggest that some predictors of MR are mutable; however, further research is needed to confirm these results.

Conclusion

This chapter adds to the literature through (a) a conceptual and theoretical review of multimorbidity resilience; and (b) advancement of a multimorbidity resilience measure developed for large population health survey data. The Lifecourse Model of Multimorbidity Resilience connects multiple resources embedded in the individual, family, community, and society, with a series of processes that occur during disruption and reintegration along a life trajectory. The non-linearity of the resilience process, and the potential for cascading crises that may restrict or delay resilient outcomes or for reversals, reflect multimorbid experiences of older individuals. This work elaborates upon pivotal resilience processes underlying the outcomes of wellness, recovery, and growth/development among older persons facing multimorbidity. Understanding resilience processes helps to understand the well-being paradox, in which individuals facing multimorbidity often redefine their well-being in positive terms as a coping mechanism. Turning to intervention research, there remains a need to locate the most mutable points in the illness-resilience cycles to maximize illness management strategies. The LMMR provides initial direction in identifying effective ways to address these issues.

This chapter also describes and validates a new multimorbidity resilience index comprising functional, social, and psychological domains with measures of adversity and adaptation. The criterion validation of the index and comparisons with similar studies provides initial support for this new measure. Further confirmatory research is needed to validate the resilience indices using other known data sets, such as the US Health and Retirement Study. In addition, these measures need to be incorporated into explanatory and predictive models in order to identify and compare determinates and outcomes, especially using longitudinal data sources. Research is also warranted to establish the full usefulness of this measure among different populations (e.g., ethnicity/race, socio-economic status, etc.), as well as applications to relevant clinical settings.

Future research that can also incorporate the stage of the comorbidity is another avenue of research; a composite resilience measure can be extended to other areas of risk, such as injury and falls. Third, identification of individuals at lower levels of resilience can be helpful in interventions aimed at improving independent community living. All of these program, policy, and clinical implications can potentially lower health care costs, extend longevity, and contribute to a healthier aging population today and in the future.

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Quantitative Approaches to Examine Resilience and Aging

Almar A. L. Kok, Martijn Huisman, Theodore D. Cosco, and René J. F. Melis

Abstract In this chapter, we review six quantitative approaches to examining resilience in the context of aging. We categorize these approaches based on the distinct statistical methods that are used to operationally define resilience: estimating "buffering" effects of hypothesized protective factors in the effect modification approach, scale construction in the psychometric approach, comparison of a profile of characteristics between groups based on predefined resilience responses in the a priori approach, data-driven subgroup identification based on resilience responses in the clustering approach, analyzing predictors of adversity-outcome residual values in the residual approach, and analyzing stressor-response patterns in high-density time-series in the complex system approach. We illustrate each of the methods with multiple examples from the literature and pay special attention to the theoretical and conceptual assumptions inherent to each approach about what resilience is and how its correlates can be identified. The approaches are not mutually exclusive. Researchers may choose to combine multiple approaches and may analyze the

A. A. L. Kok (✉)
Amsterdam UMC, Vrije Universiteit Amsterdam, Epidemiology & Biostatistics, Amsterdam Public Health Institute, Amsterdam, The Netherlands

Amsterdam UMC, Vrije Universiteit Amsterdam, Psychiatry, GGZ inGeest, Amsterdam Public Health Institute, Amsterdam, The Netherlands
e-mail: a.kok1@amsterdamumc.nl

M. Huisman
Amsterdam UMC, Vrije Universiteit Amsterdam, Epidemiology & Biostatistics, Amsterdam Public Health Institute, Amsterdam, The Netherlands

Department of Sociology, VU Amsterdam, Amsterdam, The Netherlands
e-mail: ma.huisman@amsterdamumc.nl

T. D. Cosco
Department of Gerontology Research Centre, Simon Fraser University, Vancouver, BC, Canada

Oxford Institute of Population Ageing, University of Oxford, Oxford, UK
e-mail: theodore_cosco@sfu.ca

R. J. F. Melis
Radboud University Medical Centre, Department of Geriatric Medicine, Radboud Alzheimer Centre, Nijmegen, The Netherlands
e-mail: rene.melis@radboudumc.nl

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same data using multiple approaches to compare the findings between them. After reading this chapter, the reader will be familiar with commonly used quantitative approaches to resilience, their implicit and explicit theoretical assumptions, and their strengths and limitations.

Keywords Resilience · Older adults · Quantitative approaches · Critique · Theoretical assumptions

Background

The concept of resilience is increasingly applied to aging research. Most existing definitions of resilience presuppose that it entails exposure to adversity in combination with an unexpectedly positive level of functioning given this exposure. The type of exposures examined in the context of aging range from economic hardship (Pudrovska et al. 2005) to stressful life events (Lim et al. 2015), and from experiencing functional impairment (Szabó et al. 2019a, b) to an orthostatic challenge test (Lagro et al. 2014). In addition, "protective factors," defined as "measurable characteristics of a group of individuals or their situation that predicts positive outcomes in the context of risk or adversity" (Masten et al. 2011) are hypothesized to account for positive outcomes despite adversity. Such protective factors may operate at the individual, social, and societal levels.

The concept of resilience has been receiving increasing interest from researchers on aging because older adults are often confronted with an accumulation of specific risk exposures that may threaten their functioning and well-being, for example, the death of a spouse or friends, declines in physical health, loss of social status, and ageism (Smith and Hayslip jr. 2012). The concept of resilience enables researchers to focus on interindividual differences in the ways in which older adults adapt to such exposures, and to arrive at a better understanding of the large heterogeneity in health and functioning in aging populations. To examine and operationalize resilience and identify its correlates, researchers can make use of a variety of quantitative approaches. The concept of resilience and its related research questions often require specific ways of gathering, selecting, coding, and analyzing quantitative data. Specific conceptual approaches to resilience, for example, those based on complexity science (Homer-Dixon 2011), may even require new modes of data collection and analysis (e.g., Ecological Momentary Assessment (EMA), and Measurement Burst Designs).

In this chapter, the term "quantitative approach" refers to a specific way of selecting, coding, and analyzing quantitative data that can be applied to answer research questions about resilience. After reading this chapter, resilience researchers will be able to decide which of the existing quantitative approaches may be most suitable to their research questions and their data. This chapter elaborates on six approaches

that are being applied in resilience research: effect modification, psychometric, a priori, clustering, residual, and complex system approaches. We categorize these approaches according to the kind of statistical methods that are applied in resilience research. These methods are estimating "buffering" effects of hypothesized protective factors in the effect modification approach, scale construction in the psychometric approach, comparison of a profile of characteristics between predefined groups in the a priori approach, data-driven subgroup identification in the clustering approach, analyzing predictors of adversity-outcome residual values in the residual approach, and analyzing stressor-response patterns in high-density time-series in the complex system approach. We emphasize that the distinction of these approaches is to some extent artificial: these approaches are not mutually exclusive. Similar research questions may be answered using different strategies, and these can be and often are combined in research. A practical overview of the available quantitative approaches may be helpful for resilience researchers to decide which ones are most relevant for them.

Our impression is that these approaches cover the majority of quantitative studies on resilience and aging to date. Because each quantitative approach comes with its own assumptions, strengths, and limitations that need to be considered, we pay special attention to the theoretical and conceptual assumptions inherent to each approach. In this chapter, we illustrate each of the methods with multiple examples from the literature.

Structure of the Chapter

We review six quantitative approaches to examining resilience in the following order:

- Effect modification approach
- Psychometric approach
- A priori approach
- Clustering approach
- Residual approach
- Complex system approach

The description of each method consists of four subsections:

- General description
- Theoretical assumptions
- Examples
- Strengths and limitations

After the overview of the six approaches, the chapter concludes with a general discussion that includes (i) a summary of the key differences and similarities between methods; (ii) recommendations on how to choose the appropriate method(s); and (iii) recommendations about the use of quantitative methods in examining resilience. These include carrying out sensitivity analyses to check the

robustness of one's main findings and designing analyses in such a way that they maximize the added value to the traditional epidemiological risk factor approach.

Overview of Quantitative Approaches to Examine Resilience

The Effect Modification Approach: Identifying Adversity Buffering Factors

General Description

The effect modification approach focuses on identifying factors that protect individuals against the negative effects of adversity on outcomes. Such factors are also referred to as "buffering" the effects of adversity, meaning that they are only or primarily related to the outcome of interest in persons exposed to the adversity (Cohen and Wills 1985). For example, there is a large literature focusing on the "buffering hypothesis" of social support, which posits that social support will particularly benefit well-being in stressful situations because the perception of support being present may reduce the stress appraisal or through activation of the social network may alleviate the problem itself (Cohen and Wills 1985). Statistically, testing such buffering hypotheses is often done by adding the hypothesized protective factor as an effect modifier to a regression model (Masten 2001). Technically, resilience studies most often do this by adding a product term of the adversity and the protective factor variables to a model that also includes the main effects of the adversity and the protective factor. The idea is that the effect of this additional variable shows whether the relationship between adversity and the outcome is relatively weak in those who score high on the protective factor. If this is the case, it is seen as evidence that the presence of the protective factor reduces the negative effect of the adversity on the specified outcome.

We emphasize that adding the multiplication of two variables to a regression model can also be interpreted as a statistical "interaction effect," in which the interest is merely in comparing groups with different combinations of the two interacting variables, without giving primacy in the interpretation to the causal effect of one of them (Vanderweele 2009). However, in the context of resilience it might be more appropriate to interpret it as "effect modification" because the primary interest is in the effect of the adversity and whether this effect is weaker in groups possessing higher quantities of a given buffer variable.

Theoretical Assumptions

One theoretical starting point that is explicit in the effect modification approach is that protective factors become important only when people are faced with adversity. Therefore, the method places specific restrictions on which variables qualify as a protective factor; one assumption is that it is not sufficient for the protective factor

to be associated with good outcomes in general; rather, a specific relationship between the adversity and the protective factor is assumed such that the association between the adversity and the outcome is weaker in those with high levels of the protective factor than in those with low levels.

In a hypothetical example presented in Fig. 1, we illustrate this by showing that the difference in depressive symptoms between those with high and those with low social support is larger in groups that are exposed to bereavement. In this particular example, social support is not strongly related to well-being in the absence of adversity but becomes instrumental for well-being when people are exposed to adversity. To put this in other words, those exposed to the adversity who have high levels of support are protected against the risks associated with the adversity, while those with low levels of support are not.

Examples

We provide three examples adopting an effect modification approach. Each of these examples used multiplicative interaction effects to examine "buffering" effects. Klokgieters et al. (2017) examined whether country of origin, level of mastery (i.e.,

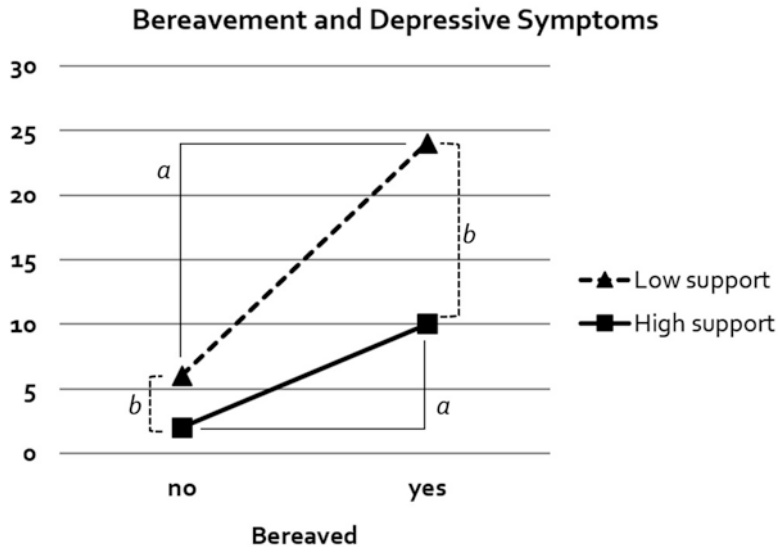

Fig. 1 Hypothetical example illustrating the interaction method. The figure plots the effect of bereavement on depressive symptoms and examines whether emotional support is a protective factor by stratifying the effects of bereavement for emotional support. The findings show that this effect is smaller for those with high support than for those with low support. This can be seen from comparing the distances indicated by "a." The same statistical results also show that while having emotional support is associated with less depressive symptoms for bereaved and non-bereaved persons, this association is stronger in the bereaved. This is indicated by the distances "b." The conclusion would be that the interaction effect provides evidence that emotional support provides resilience in the context of bereavement

perceived personal control over one's life), income, and social contact frequency moderated the progression of disablement in native Dutch and Turkish and Moroccan migrant older adults. They focused on the effect of low gait speed on activity limitations. Low gait speed was seen as an early-stage disablement indicator that increases the risk of more advanced disablement in the form of activity limitations. They found that mastery buffered this effect in Turkish migrants and the native Dutch groups and that income buffered this effect only in the native Dutch population (Klokgieters et al. 2017). Latham-Mintus and Aman (2017) examined whether various aspects of psychosocial resiliency, that is, mastery, optimism, and religiosity, moderated the effect of childhood disadvantage on later life recovery from mobility limitations. Based on the results, they conclude that a strong sense of control (mastery) might buffer the negative effects of financial hardship in childhood. In a similar vein, Pudrovska et al. (2005) found that mastery buffers the relationship between recent economic hardship on emotional (depressive and anxiety symptoms) and physical functioning.

Strengths and Limitations

A strength of the effect modification approach is that it challenges researchers to theorize about factors that play a role in protecting individuals from the risks that emerge from adverse contexts. It explicitly attempts to move beyond identifying general predictors of good outcomes, by asking which factors are of particular advantage when exposed to adversity. Therefore, protective factors that are identified using the effect modification approach may, to the extent that they are modifiable, hold promise for reducing health inequalities through interventions that target the most at-risk groups, instead of interventions that target the population at large.

A limitation of this approach is that the statistical criteria for what qualifies as a protective factor are quite stringent; the chance of finding evidence for effect modification partly depends on the strength of the effect in the group that is not exposed to adversity. Additionally, the statistical power for detecting effect modification is generally low, which might lead to incorrectly dismissing candidate protective factors. Moreover, there are multiple methods to investigate effect modification; although resilience research has most often relied on multiplying adversity and protective variables ("multiplicative interaction"), the interpretation of their effects differs depending on the effect measure used [e.g., absolute or relative; (Vanderweele 2009)], and there are additional ways of examining interaction that may be valuable for future studies on resilience, for example, calculating measures of "additive" interaction (Knol et al. 2011). Finally, the interaction method is not well suited to identify patterns or profiles of multiple factors that provide resilience because modeling and interpreting multiple effect modifiers simultaneously is complex.

The Psychometric Approach: Resilience as a Directly Observable Characteristic

General Description

The psychometric approach is often applied in psychological studies of resilience and follows methods of scale construction to determine individuals' level of resilience. That is, a summary score is constructed out of self-report items that typically intend to capture a composite of psychological characteristics that are hypothesized to be dimensions of resilience, for example, sense of control, competence, acceptance of change, initiative, emotional regulation, and positive future orientation (Windle 2011). In addition, some scales include "external" factors such as social relationship security, family coherence, and community connection (Friborg et al. 2003). Others include a temporal dimension by asking for adaptation to change. Out of 15 reviewed scales, those with the highest quality ratings in terms of reliability and validity included the Brief Resilience Scale (Smith et al. 2008), Connor-Davidson Resilience Scale (Connor and Davidson 2003) and the Resilience Scale for Adults (Friborg et al. 2003; Windle et al. 2011). We summarize the features of these scales in Table 1. It becomes clear that these scales differ strongly in their comprehensiveness. Moreover, to date, most resilience scales—including the three highlighted here—have not yet been extensively validated in older adult populations (Cosco et al. 2016).

Theoretical Assumptions

The theoretical assumptions implicit in resilience scales about what constitutes resilience differ strongly depending on the particular features of the resilience scale used. Scales that solely include items capturing a sense of personal agency give primacy to individual action as crucial to resilience. Such scales may be argued to be restricted to capturing psychological resilience only. Scales that additionally include measures of the availability of social resources adopt a more multilevel and multidimensional perspective on resilience (Windle et al. 2011).

Furthermore, what theoretically distinguishes the psychometric approach from other approaches is that it presumes that resilience can be established without exposure to the stressor and regardless of the outcomes because a resilience scale can be administered to anyone in any situation. It therefore theoretically allows for the possibility that resilience can be demonstrated outside of a situation of adversity. In addition, it is less precise than other approaches about the adversity against which the system/person is resilient, and in relation to which outcomes, because resilience is measured independent of the adversity and outcome.

Table 1 Descriptions of the three resilience scales reviewed in Windle et al. (2011) with the highest scores

	Brief Resilience Scale (BRS)	Connor–Davidson Resilience Scale (CD-RISC)	Resilience Scale for Adults (RSA)
Reference	Smith et al. (2008)	Connor and Davidson (2003)	Friborg et al. (2003)
Number of items	6	25	45
Dimensionality	One dimension	Five dimensions	Five dimensions
Description of items or dimensions (including an example item)	Separate items: 1. I tend to bounce back quickly after hard times 2. I have a hard time making it through stressful events 3. It does not take me long to recover from a stressful event 4. It is hard for me to snap back when something bad happens 5. I usually come through difficult times with little trouble 6. I tend to take a long time to get over setbacks in my life	Dimensions: 1. Personal competence, high standards, and tenacity ("you work to attain your goals") 2. Trust in one's instincts, tolerance of negative affect and strengthening effects of stress ("you have to act on a hunch") 3. Positive acceptance of change and secure relationships ("you are able to adapt to change") 4. Control ("you are in control of your life") 5. Spiritual influences ("sometimes fate or God can help")	Dimensions: 1. Personal competence ("I believe in my own abilities") 2. Social competence ("I am good at getting in touch with new people") 3. Family coherence ("there are strong bonds in my family") 4. Social support ("I have some close friends/family members who really care about me") 5. Personal structure ("rules and regular routines make my daily life easier"

Examples

The psychometric approach is often used in conjunction with the effect modification approach. In these cases, an individual's level of resilience is first measured with a resilience scale [e.g., the Connor–Davidson resilience scale (Connor and Davidson 2003)]. Subsequently, we investigate whether the effect of adversity on the outcome of interest is weaker for participants scoring higher on the resilience scale than for participants scoring lower on the resilience scale (which is often referred to as a "buffering" effect; see Section "General description").

Starting from the observation that with increasing life expectancy, more individuals will be confronted with ill health in old age, Windle et al. (2009) asked whether having a "resilient personality" acted as a buffer against the negative effects of chronic somatic disorders on well-being in old age. Their study aimed to contribute evidence to theories on the role of within-individual regulatory processes in

resilience, for example, the Stress Process Model and Continuity Theory, by focusing on psychological factors. The scale they used included items on self-esteem, interpersonal control, and personal competence that were hypothesized to be manifestations of the single underlying construct of resilience (Windle et al. 2008). The study found a relatively weak effect of ill-health on well-being for those with high resilience scores.

Lim et al. (2015) examined whether scores on the Connor–Davidson resilience scale moderated the effect of stressful life events on depressive symptoms. They argue that a combination of psychological and social factors may be crucial for protecting older adults against the potential adverse effects of stressful life events on well-being. Using multiplicative interaction they found that for participants scoring high on the "sense of personal competence and optimism" dimension of this scale, the effect of life events on depressive symptoms was weaker than in those scoring higher on the scale. No effect modification by the "commitment and perseverance" and "independence and self-esteem" dimensions were found. The authors argued that the latter two dimensions may be less relevant in the face of "acute" stressors that they studied, such as the death of significant others and major accidents.

Strengths and Limitations

Using established resilience scales potentially increases comparability between studies because multiple studies can use exactly the same questionnaires to examine resilience. In addition to comparisons between different study samples, it can be useful for examining within-person change in resilience factors, as the same measurement instrument can be applied repeatedly within the same study sample. In this case, measurement invariance and reliability across measurement waves should first be established. In terms of time investment (respondent burden, data cleaning and management), the psychometric method may be an effective and efficient choice, particularly if one uses relatively short resilience questionnaires. Furthermore, resilience can be measured at all times, also in unstressed situations, which could be an advantage in studies with infrequent measurements in which the occurrence of many acute stressors may be missed.

If one is interested in a multilevel conception of resilience, a current disadvantage of resilience scales is that most of them consider only a limited number of protective factors, particularly psychological traits, while there often are many more, such as family and community resources (Huisman et al. 2017). However, resilience scales including individual and social factors might not be appropriate to use as a single scale because they represent different dimensions that cannot statistically be seen as measuring a single underlying construct. If this is the case, psychological and social factors cannot be assumed to contribute equally to the overall resilience score. In addition, few studies have validated resilience scales in older populations (Cosco et al. 2016). Some studies have found expected correlations between resilience scales and general health, and mastery and social support (Bousquet et al. 2015), but it is unclear to what extent these outcomes are actually

relevant for demonstrating external and construct validity. In addition, factor structures found in resilience scales that are developed in younger populations often do not (completely) replicate in older populations. Given the changing exposures to specific stressors and the psychosocial changes with aging, this raises the question whether the scales capture the same phenomena in older adults (Cosco et al. 2016).

The A-Priori Method: Researcher-Defined "Resilient" Subpopulations

General Description

The essence of the a priori method is that individuals are categorized into groups with specific combinations of levels of adversity and outcomes. This means that researchers define in advance (a priori) the criteria that individuals need to fulfill to qualify as "resilient." These criteria at least involve having been exposed to adversity and having an outcome that is considered as favorable given the exposure to adversity. In most a priori approach studies, researchers decided on the cut-off points for the adversity and the outcomes themselves. This can be done by using absolute (e.g., scoring below or above a cut-off point that has been agreed upon as a clinically relevant level of depressive symptoms) or relative (e.g., being among the top third functioning participants in the sample) criteria. Data-driven techniques such as latent class analysis can also help to distinguish between groups with high versus low adversity, or favorable versus unfavorable outcomes (we discuss this approach in more detail in Section "Clustering approach: Data-driven techniques to identify 'resilient' subpopulations"). Furthermore, the a priori definition is sometimes used to identify groups that can be targeted for in-depth qualitative research, rather than a quantitative comparison (Hildon et al. 2008; Kok et al. 2018).

The number of groups that is distinguished differs among studies and may depend on sample size considerations and on whether or not researchers include a group that is not exposed to adversity. Figure 2 shows an example that includes groups exposed and unexposed to adversity, and in which adversity and outcome are dichotomized. This results in four groups. Group A is the resilient group, which is exposed to adversity but has a favorable outcome. Because this is in line with what would be expected on the basis of their exposure to adversity, Group B is labeled "normative." The other "normative" group is Group C, which has not been exposed to adversity and—in line with the absence of adversity—has a favorable outcome. Finally, Group D consists of individuals who are not exposed to the adversity of interest yet have an unfavorable outcome, suggesting that the group may have been exposed to other risks that have not been measured or are outside the scope of the study. Following Fergus and Zimmerman who labeled this group "Inadequate risk assessment" (2005), we therefore labeled this group "unmeasured risk".

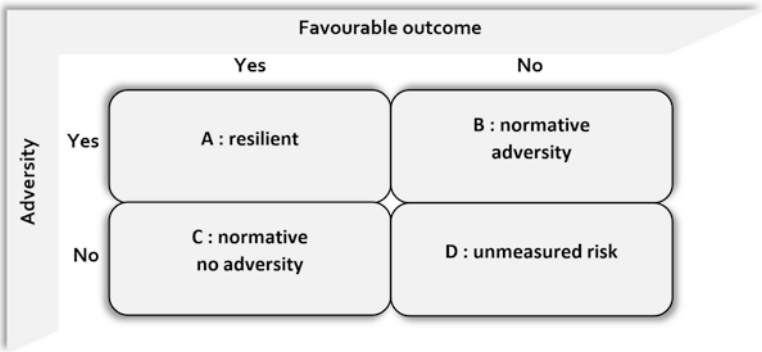

Fig. 2 The a priori approach defines a group of study participants as "Resilient" based on pre-specified criteria of adversity and outcome. Characteristics of the resilient group can be compared to those of other groups. Not all studies include groups that are not exposed to adversity. Such studies focus only on differences within those exposed to adversity

The next step is to establish to what extent the level of hypothesized protective factors differs between the groups, for example, by analysis of covariance (ANCOVA) or (multinomial) logistic regression. In studies employing the a priori approach, the difference in characteristics between Groups A and B are usually central to examining resilience. Hypothesized protective factors that are more prevalent in Group A compared to Group B are seen as contributing to resilience.

However, comparing the characteristics of the Resilient with Group C may be additionally valuable. It may indicate to what extent the characteristics of the so-called Resilient are exceptional given that they have similarly favorable outcomes as Group C but have done so in an adverse context (Masten and Obradović 2006).

Differences between the Resilient and Group D (unmeasured risk) are often not discussed in studies as they are usually small (Masten and Obradović 2006) and differ both on the adversity and outcome variables, making it difficult to determine whether differences in protective factors are related to differences in exposure to adversity or to differences in outcomes, or both.

Theoretical Assumptions

Although the a priori approach does not deny that a continuum of resilience may exist, one theoretical assumption is that resilience can only be observed in groups that are actually exposed to adversity and that it cannot be established whether those not exposed to adversity would have been resilient—at least by the operational definition chosen in the particular study.

In Fig. 2 we notice that, usually, studies consider the finding that the third factor is more favorable in Group A (the resilient) than in Group B (Normative Adversity) as evidence that this factor protects against the risks of the adversity (Kok et al. 2019; Masten et al. 1999; Netuveli et al. 2008) . However, it has been suggested that

a comparison between Group A and Group C is also theoretically relevant, as this might indicate whether exceptional levels of the protective factor are required in the context of adversity to attain similar outcomes to those who have not been exposed to adversity (Kok et al. 2019; Masten and Obradović 2006).

Examples

Hildon et al. (2008) used life grids and interviews to quantify recent exposure to adversity, defined as (combinations of) exposure to negative life events, having a chronic illness or recent deteriorating health, or increases in stress in adults aged 70–80 years from the British Boyd Orr cohort. They applied a median split on quality-of-life scores (the outcome variable) within those exposed to at least some of these adversities—and excluded participants not exposed to adversity. They then compared the groups with high versus low quality-of-life scores using quantitative data and qualitative interviews. They concluded that because social networks and effective coping strategies were important for both vulnerable and resilient groups, it is unlikely that such factors are themselves features of resilience. However, the qualitative interviews suggested that a high *stability of* social networks and psychological coping strategies over time were decisive for resilience.

Netuveli et al. (2008) used data from more than 3500 participants aged 50 or over from the British Household Panel Survey and defined resilience a priori as recovery of mental health (measured by the General Health Questionnaire) to pre-adversity levels after experiencing the onset of functional limitations, bereavement, marital separation, or poverty. Based on the groups made with these criteria, they found that 14.5% of the sample was "resilient," and they identified high social support as a primary predictor of having a resilient pattern.

As a third example, Kok et al. (2019) used a combination of data-driven and researcher-defined cut-off points to identify a resilient group. Employing data from a birth cohort study, the MRC National Survey of Health and Development, they used latent class growth analysis (LCGA) to distinguish three levels of lifetime exposure to socioeconomic adversity, while a favorable outcome was defined as remaining free from functional limitations at age 60–64 years. This resulted in six groups. By applying ANCOVA and logistic regression, they found that remaining free from childhood illness, relatively high levels of self-management in adolescence, and not becoming obese were associated with resilience.

Strengths and Limitations

A strength of the a priori approach is that it is easy to use extensive amounts of (already collected) data to identify relevant subgroups and create profiles of characteristics that distinguish these groups from other subgroups. This is different from, for example, the effect modification approach, which relies on average effects

between variables (adversity and outcome; interactions between adversity and protective factors) and therefore remains implicit about what level of outcomes is indicative of resilience. Compared to the psychometric approach, which relies on a fixed set of potential protective factors included in a resilience scale, the a priori approach forces researchers to carefully select outcomes and protective factors that are relevant to the context of the specific stressor at hand (Huisman et al. 2017).

Nevertheless, because the approach relies on comparing specific groups, the a priori approach requires a crude ad hoc categorization of individuals, which may be a disadvantage particularly with smaller samples that may have limited statistical power to detect differences between subgroups. Additionally, in many cases there are no agreed-on cut-off points for distinguishing high from low adversity, or "good" from "bad" outcomes, and the results may be sensitive to the chosen cut-off points. As an alternative, data-driven approaches may be used to distinguish resilient subgroups in a given sample (See Section "Clustering approach: Data-driven techniques to identify 'resilient' subpopulations"). In the effect modification approach, this limitation can be avoided by using continuous adversity and outcome variables. Finally, there seems to be a lack of consensus about how "protective" factors should be distinguished statistically; specifically, it is unclear whether including a group that has not been exposed to adversity, and testing differences in their characteristics with the Resilient group, improves inferences about resilience (Masten and Obradović 2006).

Clustering Approach: Data-Driven Techniques to Identify "Resilient" Subpopulations

General Description

With an increasing availability of advanced statistical methods, clustering techniques are increasingly applied in resilience research on older adults (Infurna and Grimm 2017). Clustering techniques are designed to identify subgroups of individuals with particular (combinations of) characteristics that distinguish them from other subgroups in a larger population. The algorithms used in these techniques are designed to search for a best-fitting statistical solution that maximizes differences between and minimizes differences within subgroups. One way in which this method can be applied is to identify a "resilient" group that is characterized by exposure to adversity yet shows relatively good levels of functioning in a single step. In this case, variables measuring adversity as well as functioning should be included simultaneously in the analysis (e.g., Szabó, Klokgieters, et al. 2019a, b). This approach matches the conceptual idea of resilience well as resilience is typically concerned with identifying subgroups with a particular, and sometimes unusual or unexpected, combination of characteristics that enable them to recover from or to resist adversity. Clustering techniques may help to detect such subgroups.

Alternatively, rather than analyzing adversity and outcomes in a single model, clustering techniques can be used to identify groups with distinct patterns of exposure to adversity (e.g., Kok et al. 2019), or groups with distinct outcome trajectories separately (McDermott et al. 2017).

When researchers who apply clustering techniques define in advance which variables are included as measures of adversity exposure and which variables as outcomes, clustering techniques can be seen as a variation of the a priori approach. However, in contrast to the a priori approach as described above, cut-off points and subgroup identification in clustering techniques are data driven. This also means that the results are based on the variation that is present in the sample. Hence, although the adversity and outcome variables are defined "a priori," the cut-off points used to identify resilient subgroups are not.

To further illustrate how this quantitative approach works, we elaborate on one particular clustering technique that is often used in resilience research and is available in multiple software packages: latent class analysis (LCA), also referred to as "mixture" modeling (Muthén 2004). In latent class analysis, the number of subgroups that fits the observed data best is derived during an iterative process. In addition to statistical fit, theoretical interpretation should guide the final model selection (Muthén 2003). As in the a priori approach, researchers then typically examine whether a range of hypothesized protective factors differ between the resilient subgroup and other subgroups.

In addition to cross-sectional categorical or continuous data, latent class models can be used to identify subgroups in longitudinal data. These models can be extended to incorporate multiple parallel longitudinal outcomes, complex growth parameters (e.g., quadratic and cubic slopes), or "piecewise" or "multiphase" trajectories (e.g., pre- and post-adversity; (Kim 2014; Kim and Kim 2012)). Other techniques may be equally suitable for use in resilience research, for example, regression tree classification (Cairns-Nagi and Bambra 2013) and sequence analysis (Han et al. 2017). Furthermore, recent developments in machine learning offer new applications of clustering techniques, in which adversity and outcome variables need not necessarily be specified to identify individuals with resilient patterns of functioning (Galatzer-Levy et al. 2018).

Theoretical Assumptions

In the context of resilience research, clustering techniques can be seen as sophisticated methods for data reduction that enable researchers to identify meaningful subgroups in complex data. One important characteristic of clustering techniques, however, is that they are not deterministic, but probabilistic. In the case of latent class analysis, this means that rather than unambiguously belonging to a single latent class, individuals have a *probability* of belonging to each identified latent class that ranges between 0 and 1. However, after identifying subgroups and examining whether they differ in protective factors, researchers often introduce the assumption that class membership was observed rather than estimated. Particularly

if the classification quality is poor, conclusions about the factors associated with resilience may be biased, and researchers should consider applying techniques that take classification uncertainty into account (see for overviews of currently available techniques: Bray et al. 2015; Collier and Leite 2017).

Examples

In resilience research, clustering techniques have been applied in a number of different ways. First, latent class analysis can be applied to cross-sectional data to identify a subgroup of participants with particular combinations of exposure to adversity and outcome. In this approach, both the adversity and outcome variables are entered into the latent class model. For example, Szabó and colleagues (2019a, b) examined whether a subgroup of immigrant older adults in the Netherlands could be identified, who had functional impairments yet retained a low level of depressive symptoms. Such a group was indeed identified in the best-fitting LCA. The latent class variable was used in a secondary analysis to examine whether hypothesized protective factors differed between this resilient group and groups with other combinations of functional limitations and well-being (Szabó, Klokgieters, et al. 2019). Resilient migrants were characterized by a low level of loneliness, higher mastery, and religiosity but by poorer Dutch language proficiency. The authors suggest that the latter finding may be explained by the integration paradox, stating that better knowledge of the receiving country may also lead to higher exposure to the exclusionary aspects of not being native to that receiving country (Szabó et al. 2019a, b).

Second, LCA has been used to examine intra-individual heterogeneity in outcome trajectories within a group exposed to a specific and discrete adversity. For example, McDermott et al. (2017) used growth mixture modeling to identify a cluster of resilient individuals who retained high episodic memory functioning despite genetic risk factors for Alzheimer's Disease (APOE ε4 and Clusterin). After establishing latent class membership, they used a random forest algorithm to identify factors related to resilience. Among the multitude of factors associated with resilience were younger age, higher education, higher grip strength, everyday cognitive activity, and being married. Another example study used LCGA to examine trajectories of depressive symptoms and emotional and social loneliness pre- and post-bereavement and for each outcome identified a "resilient" group that showed no long-term negative emotional responses to bereavement (Szabó et al. 2019a, b). The percentage of older adults with *resilient* trajectories (stable high emotional functioning) was 15.5% for depressive symptoms, 13.5% for emotional loneliness, and much higher, about 70%, for social loneliness. This study did not examine whether particular participant characteristics were associated with resilient trajectories.

Strengths and Limitations

The main strength of applying the clustering approach in resilience research is that it uses techniques that can identify (small) subgroups that demonstrate resilient patterns of functioning, even in complex multivariable and longitudinal data, for which it would be difficult to establish a priori criteria. A further methodological advantage is that most clustering techniques by default use contemporary methods to account for missing data and are able to accommodate a wide variety of variable types, including categorical, count, and skewed distributions.

A limitation is that the results of clustering techniques depend on the variation in the sample. Therefore, resilience determined through clustering techniques is relative to the population, which hampers reproducibility in other samples and reduces generalizability, whereas researcher-defined cut-off points as sometimes applied in the a priori approach increase replicability.

Residual Approach: Positive Deviations from a Regression Line as Indicator of Resilience

General Description

In the residual approach, the central premise of the concept of resilience is "functioning better than expected"—and this premise is operationalized as having a positive deviation from the regression line that reflects the average effect of the adversity on the outcome. Typically, the level of functioning decreases as exposure to adversity increases, either linearly or non-linearly, and in the residual approach, anyone with a better outcome than would be predicted on the basis of this regression model is considered as "resilient."

The first step in this approach is to regress the outcome of interest on the adversity. Second, the deviations of each observed individual outcome score from the scores predicted by the regression equation, also known as "residuals," are saved into a new variable. A residual value of zero means that the individual has exactly the outcome that would be predicted, given their level of adversity. A positive residual value means that the outcome is better than would be predicted given the level of adversity, and vice versa for negative residuals. Hence, the new variable places individuals on a continuum from resilient (positive residual) to vulnerable (negative residual; see Fig. 3). Third, a regression model is estimated with the residuals as outcome and factors hypothesized to be protective as independent variables. Any factor that is positively associated with the residual scores is then considered to be protective and to contribute to resilience.

Alternatively, individuals could be categorized based on their residual score and their exposure to adversity. For example, those with high adversity and positive residuals can be categorized as resilient and compared with other groups,

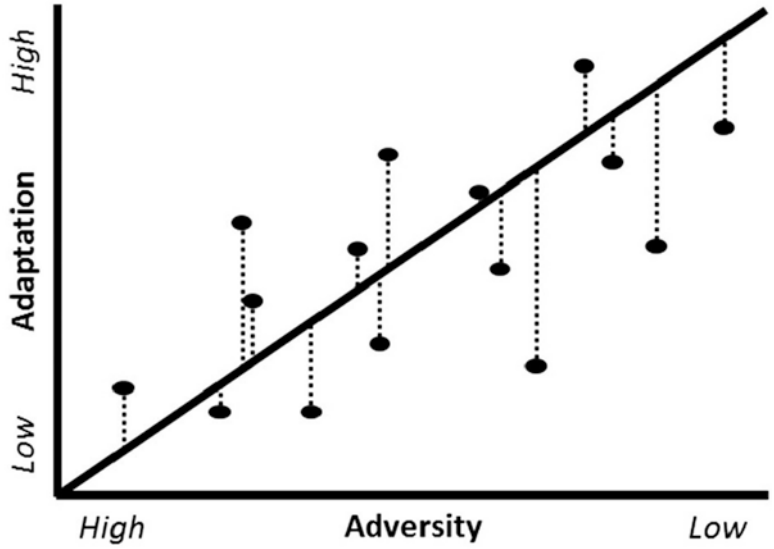

Fig. 3 Plot illustrating the residual approach. The residual values, that is, the distance from the fitted regression line indicated by the dotted line, quantifies the level of resilience/vulnerability. (Figure from Cosco et al. 2019)

comparable to the a priori approach (see Section "The a-priori method: Researcher-defined 'resilient' subpopulations").

Theoretical Assumptions

Basic assumptions of regression apply to this approach (e.g., residuals should be normally distributed; non-linearity of the adversity-outcome effect should be tested and modeled if necessary). Furthermore, in studies that include older adults with and without exposure to adversity, the residual method assumes that resilience is possible in a context with low adversity. This is because the regression line is estimated on the basis of outcomes at all levels of adversity, and an individual with low exposure to adversity may nevertheless be functioning better than expected based on the regression equation, and be considered "resilient" (see, for example, the first data point in Fig. 3). Another assumption when modeling the effect of a hypothesized protective factor on the residuals is that the effect of the protective factor is assumed to be equal at all levels of adversity because the residuals represent the variation that is left after adversity is taken out of the regression equation (see Section "Strengths and limitations").

Examples

Pearson et al. (2013) used residual scores to identify "resilient" geographical areas in New Zealand, defined as having lower-than-expected mortality rates despite neighborhood socioeconomic deprivation. They constructed a "Resilience Index" based on standardized deviance residuals obtained from a regression of mortality on neighborhood deprivation, categorized into quintiles. They found that resilient neighborhoods were typically densely populated urban areas with better access to safe drinking water and greater distances from gambling facilities and alcohol outlets. However, they also had higher proportions of short-term residents, more social fragmentation, and a low level of volunteerism—factors that might be interrelated. The authors speculate that the low mortality rates in the resilient neighborhoods may partly be due to the high percentage of short-term residents, but without further study to determine the reasons for this high percentage, it remains unclear whether this is a true sign of resilience or not.

Another example employing the residual method comes from Cosco et al. (2018), who operationalized resilience as having higher-than-expected well-being given the level of physical functioning. Residuals obtained from the regression of well-being on physical capability were regressed on several hypothesized protective factors: childhood and adult socioeconomic position, social mobility, physical activity, and social support. They found that higher adulthood social class, greater physical activity and having more social support were associated with more positive residuals, that is, higher resilience.

Strengths and Limitations

Strengths of the residual approach are that it quantifies resilience on a continuum, which may be a more realistic operationalization than when resilience is categorized, as is often (but not necessarily) the case in studies employing an a priori approach. In addition, it maximizes statistical power. Furthermore, the use of residuals reflects a direct and intuitive operationalization of the universal definition of resilience, that is, functioning better than expected, given the level of exposure to adversity.

A limitation of the residual method is that it requires all assumptions of regression analysis be met, particularly that the regression residuals are normally distributed. Furthermore, in most cases the regression line is based on information from all participants, including those with very low levels of adversity. It may be argued that this neglects the theoretical premise that resilience can only be demonstrated in the presence of adversity, and that the hypothesized "protective factors" exert their effects differently in persons who have been exposed to substantial adversity compared to those who have not.

Therefore, if one fits a regression line based on a sample of persons with lower and higher exposure to adversity, it is questionable whether finding that a third factor is associated with the residual values is indeed evidence that this factor helps

individuals to bounce back from adversity. This is because statistically, the residuals represent the variation that is left after the adversity has been taken out of the equation—or has been held constant. Finding an association between a third factor and the residuals thus basically means that rather than predicting good functioning *in the face of* adversity, this association should be interpreted as the third factor being related to better outcomes *at all levels of adversity*. Distinguishing between levels of adversity, for example, by examining interaction effects between level of adversity and the potential protective factors (see Section "The effect modification approach: Identifying adversity buffering factors") may provide more compelling evidence.

Complex System Approach: Dynamical Patterns in the Face of Challenge

General Description

The starting point of the complex system approach is that human resilience can be conceptualized as an emergent feature of a complex system (Scheffer et al. 2018). Resilience is the dynamical process—occurring across multiple spatial and temporal scales—of the response of a person to a stressor. Originating from this understanding of resilience is a number of specific indicators (or predictors) of resilience that are based on the dynamical, observed behavior of the system in response to a (real-life) stressor. In contrast to the indicators used in most other quantitative approaches of resilience, which often (but not necessarily) examine structural and relatively static characteristics such as socioeconomic position and coping abilities, these indicators tap into the processes operating within the system that is studied. Typically, research applying the complex system approach uses a dense series of repeated measurements around natural or artificially provoked stressors (Kalisch et al. 2017; Ram et al. 2014), for example, obtained with Ecological Momentary Assessments and wearables. In contrast to the other quantitative approaches, the complex systems approach is often applied in an experimental setting. Therefore, the terminology of these studies often differs from that used with approaches that tend to use data from observational studies. For example, complex system studies often use the term "perturbations" or "stressors" instead of "adversity," which is why we will use the former terms in this section.

There are two main classes of indicators of resilience in a complex system approach: Dynamical Indicators of Resilience (DIORs) and stimulus–response-based indicators (Varadhan et al. 2008).

The idea behind DIORs is that an individual's resilience can be derived from the pattern of fluctuations in a person's functioning (e.g., activity, well-being, heartrate, glucose). Thus, DIORs use the variability and fluctuations captured by time series of momentary states in rest and during particular stress situations to make inferences about responses to future stressors. There is a wide variety of DIORs, based

on various conceptualizations. One of these concepts is "critical slowing down" (Scheffer et al. 2009), which entails that complex systems (such as humans) are characterized by stable states that are separated by critical transitions or tipping points. Critical slowing down is the phenomenon that the system of interest recovers more slowly from natural perturbations and stressors occurring throughout the life course. The slower recovery indicates less resilience of the stable state the system is currently in and a higher probability to shift to an alternative state. A typical example from geriatric medicine is a person who shifts between periods without and with delirium, which are considered as "dramatic" or "critical" transitions that are observable at the whole person level. It is argued that in time series, increases in variability of functioning over time (Chaves et al. 2008), increases in the temporal autocorrelation between individually repeated measures (Gijzel et al. 2018) and increases in inertia (Kuppens et al. 2010) indicate less resilience. For reasons of brevity, we do not elaborate in detail on other DIORs that are based on the concepts of "loss of complexity" (Lipsitz and Goldberger 1992) and "changes in response distributions" (Fossion et al. 2018).

The indicators based on the stimulus-response paradigm follow from the idea that one can perturbate a system mildly under test conditions through a stress test and that the response to such a standardized perturbation is informative about the response of the system when facing a real stressor. Rather than observing responses to naturally occurring stressors as typically used to derive DIORs from time series, stimulus–response-based indicators rely on stress tests that apply a safe, known, and standardized stressor, with the aim to follow the system's response in terms of resistance (how much is the functioning of the system impaired following the stressor?), recovery (how complete and fast is the recovery?), and fatigability (how fast can the system be drained of its resources?).

Most of the DIORs and stimulus–response-based indicators have been developed in specific disciplines, but the principles are generic and can be applied to a wide range of stressors and aspects of functioning. Furthermore, classes of indicators can be combined, and the complex system approach can also be combined with other quantitative approaches described in this chapter. Finally, understanding of individual resilience in old age from a complex systems perspective can also be improved by adopting insights from multilevel perspectives on resilience, such as disaster resilience (see Linkov et al. chapter, "Science and Practice of Resilience: Disaster Systems Applications to Aging Resilience").

Theoretical Assumptions

As mentioned earlier, in the complex system approach, resilience is understood as an emergent property that can be observed only if a system is challenged (either in a natural or experimental setting). Hence, resilience is a latent construct that cannot be directly measured ahead of the stressor (Links et al. 2018). The conceptualization of resilience as a specific pattern of functioning around a stressor implies that resilience is regarded as a set of outcome trajectories rather than as a predictor or a predisposition (Kalisch et al. 2017).

Given the time resolution at which they are measured, this dynamical character is also what distinguishes resilience from more or less stable psychological traits such as personality and gender (Hamaker et al. 2007) or physical structural characteristics such as age, sex, frailty, and multimorbidity (Whitson et al. 2018). The relation between frailty and physical resilience may help to further clarify the complementarity of both types of indicators of resilience: "If the spectrum from robustness to frailty reflects the amount of physiological potential one has to react to stressors, physical resilience refers to the actualization of that potential" (Whitson et al. 2018, p. 3). Of course, this does not mean that relatively static factors reflecting the reserve of the system cannot serve to predict resilience.

Beyond these general theoretical assumptions, each of the different indicators of resilience used in the complex system approach has its own specific theoretical assumptions about resilience, and they are based on different conceptualizations (e.g., resilience as temporal autocorrelation or as fatigability). A detailed description of these assumptions is beyond the scope of this paper but can be obtained from the literature provided.

Examples

In medicine and physiology, many examples are available that can potentially be informative about the resilience of persons or their subsystems using a stimulus–response-based approach, for example, the orthostatic challenge test (Lagro et al. 2014), oral glucose tolerance test (Dunseath et al. 2019), and a grip strength test (Bautmans and Mets 2004). Lagro et al. (2014) used continuous blood pressure measurements to establish the blood pressure response after active standing up in 238 older persons visiting a falls outpatient clinic. They related the response patterns (full recovery, partial recovery, no recovery) to survival over a median follow up of 21 months. People in the no recovery group had an excess mortality in comparison to those in the full recovery group (hazard ratio 3.0 [95% confidence interval 1.2–7.7]). This shows how the straightforward test of an orthostatic challenge may be informative about the resilience of individuals (Lagro et al. 2014).

An example of a study using DIORs comes from Gijzel et al. (2017), who used a time series of 20 nursing home patients to establish if indicators of critical slowing down (i.e., temporal autocorrelation, variance) were related to frailty levels. The 20 participants of this study self-reported their physical, mental, and social functioning on a daily basis during 100 consecutive days. Here, frailty was used as a proxy for resilience, assuming that higher levels of frailty reflect less physical reserve and thus less resilience. Increasing variance and cross-correlations of self-reported functioning were indeed related to increased frailty, and the temporal autocorrelation—the third indicator of critical slowing down—was only associated with the physical functioning time series ($p = 0.06$), and to a lesser extent to mental functioning (Gijzel et al. 2017).

Strengths and Limitations

The main strength of the complex system approach is the wealth of new classes of resilience indicators that can theoretically be derived from time series data. It can be argued that the complex system approach reflects the dynamical, context-dependent nature of resilience better than structure-based indicators, in which case they are an important complement to the existing knowledge of resilience. Moreover, time series are increasingly available: it becomes more and more feasible to follow persons over time through wearables, social media, and registries. This renders resilience studies using a complex system approach increasingly feasible.

Still, there are challenges that remain to be resolved. There are situations in which it is not possible or preferable to apply a stress test. Moreover, stress tests can only be applied at discrete points in time, and this limits their use to follow changes in resilience in a context of repeated (smaller) stressors. DIORs based on free-living time series may be helpful in this regard. Second, practical and technological barriers still exist to capture and analyze time series data at scale. For time series captured under free-living conditions, the minimization of noise (due to all kinds of artefacts and disturbances) is a particular challenge of DIORs. Whereas most time series assessments rely on the response of the individual to natural stressors, they do not take into account (or even capture) the severity or stability of the stressor. Additionally, while the standardization of stress tests used in the stimulus–response-based approach solve this specific difficulty of the DIOR approach, the development of tests that are safe to execute and are intensive enough to be informative is still in its infancy. Finally, we are only at the beginning of the development and validation of DIORs and stress tests as markers of resilience, and much remains to be established about the range in which these operate, their reliability, validity and responsiveness, and their additional value over structure-based indicators.

General Discussion

In this chapter, we provided an overview of six quantitative approaches to examining resilience: the effect modification, psychometric, a priori, clustering, residual, and complex system approaches. For each of these approaches, we provided a general description and some examples and discussed their theoretical assumptions, strengths, and limitations. We have summarized these elements in Table 2 to facilitate a comparison of the approaches.

Table 2 Summary of six quantitative approaches to examining resilience

	Effect Modification	Psychometric	A priori	Clustering	Residual	Complex System
General description	Identifies variables that "buffer" the negative relationship between adversity and outcomes through testing statistical interaction effects.	Creates summary scores based on multiple self-reported items that measure (mostly psychological) factors hypothesized to contribute to resilience.	Researchers define the criteria that individuals need to fulfill to qualify as resilient. Characteristics of resilient individuals are compared with those of individuals in other groups.	A statistical algorithm identifies subgroups by maximizing differences between and minimizing differences within groups, potentially revealing a resilient subgroup.	Residual values from the average regression effect of adversity on an outcome indicate resilience/ vulnerability. Residuals are regressed on "protective" factors.	Pattern of functioning after a real-life or induced stressor is examined with high-frequency repeated measurements. Specific patterns indicate resilience.
Theoretical assumptions	Factors are deemed "protective" only if they are more strongly related to good outcomes in individuals exposed to adversity compared to those not exposed.	Depend on the items included in scales, e.g., only psychological or also social. Assumes that (potential) resilience can be demonstrated also in the absence of adversity.	Resilience can only be observed in the presence of adversity. Having more favorable characteristics than the adversity/ low-functioning group is indicative of resilience.	Subgroup membership is probabilistic rather than deterministic.	There is a continuum from vulnerability to resilience, and this should be normally distributed. Resilience can be observed also in the absence of adversity.	Resilience is an "emergent property" of individuals in the face of a challenge. This property can be observed through a specific set of outcome trajectories.
Examples	Klokgieters et al. (2017), Latham-Mintus and Aman (2017), Lim et al. (2015), Jopp and Smith (2006), and Pudrovska et al. (2005)	Windle et al. (2011), Lim et al. (2015), and Alex (2010)	Kok et al. (2019), Kok et al. (2018), Netuveli et al. (2008), and Hildon et al. (2008)	Szabó et al. (2019a, b), McDermott et al. (2017)	Cosco et al. (2018), Pearson et al. (2013)	Gijzel et al. (2017), Lagro et al. (2014)

(continued)

Table 2 (continued)

	Effect Modification	Psychometric	A priori	Clustering	Residual	Complex System
Strengths	Challenges researchers to identify factors that have specific importance in relation to adversity, rather than associated with good outcomes regardless of adversity.	Resilience is easy to assess. Relatively high comparability and replicability.	Can accommodate a wide range of variable types. Easy to identify profiles of factors contributing to resilience.	Can accommodate a wide variety of variable types and cross-sectional as well as longitudinal data.	Resilience can be operationalized as a continuum. This increases statistical power.	Provides a wealth of new indicators based on a process-based conception of resilience.
Limitations	Stringent criteria for what qualifies as a protective factor. Statistical power is relatively low due to stratification. Hard to identify profiles of multiple factors that contribute to resilience.	Existing scales mostly focus on psychological resilience only. Few resilience scales have been validated in older adults.	Requires categorization of individuals into a limited number of groups, which decreases statistical power. Results may be sensitive to the chosen (or data-driven) a priori criteria.	Results depend on the variation in the sample, leading to low reproducibility and generalizability. Methods to account for classification uncertainty are currently limited.	Assumptions of regression should be met. Cannot directly demonstrate whether third factors are protective in the face of adversity, or associated with good outcomes regardless of adversity.	Can be applied only to specific types of real-life or induced stressors. Requires intensive measurement and analysis methods that are still in an early stage of development.

Three Central Theoretical Issues

From the overview in Table 2, it is clear that the six approaches vary widely in their application of statistical methods, from testing interaction effects to constructing specific scales and from using algorithms to detect resilient subgroups in large samples to measuring response patterns to adversity using intensive time series data. In other words: each approach uses different statistical methods to examine resilience. In contrast, the variation in terms of theoretical assumptions about resilience can be summarized by three central theoretical issues.

The first is about whether resilience is regarded as a continuum that can also be observed with minimal exposure to adversity, or only in the presence of a (substantial) adversity. Whereas the effect modification, a priori, clustering, and complex system approaches require adversity to be present to be able to demonstrate resilience, the psychometric and residual approaches assume that resilience can also be observed in the absence of adversity. For the latter two approaches, one could argue that having high scores on a resilience scale or having a large positive residual in the absence of adversity is indicative of one's *potential* to demonstrate resilience when adversity occurs. An interesting suggestion for future studies would be to examine the predictive validity of observing resilience in the absence of adversity, by following up on "resilient" individuals in the absence of adversity and then examining how they respond to a future stressor once it occurs.

The second theoretical issue is what exactly qualifies as a "protective" factor. In this respect, the effect modification approach appears to impose the most stringent criteria on what is considered to be evidence that a factor is "protecting" against the risks associated with a specific adversity. This is because only those factors that "buffer" the average effect of adversity on the outcomes are seen as protective. We have highlighted this precondition as a theoretical strength because it forces researchers to critically search for resources or assets that can help individuals overcome the specific risks arising from the adverse context, rather than to regard any factor that is positively associated with good functioning in general to be contributing to resilience. A priori approaches based on group comparisons, clustering approaches, or the complex system approach do not necessarily apply such criteria, although additional statistical tests (namely, of effect modification) may be used to examine whether factors have particular significance in the context of a specific adversity.

The third important theoretical issue is whether resilience is regarded as a stable or dynamic feature of individuals. While all approaches can be used in a longitudinal, dynamic setting, the complex system approach most strongly adopts the idea that resilience is a dynamic and emergent, situational feature that only becomes apparent when a person is put under strain, and where the whole context of that situation plays an important role in whether a person is able to show a resilient response or not. Although complex system approaches do not assume that stable characteristics are unimportant for resilience, other approaches, such as the psychometric approach, more explicitly incorporate the possibility that resilience in the face of

adversity can be understood from relatively stable features such as personality characteristics alone.

Recommendations

On the one hand, the flexibility of quantitative approaches to examine resilience is a great asset for researchers. On the other hand, some approaches are more readily applicable to specific research questions and types of data than others. For example, if one aims to identify a profile of characteristics associated with resilience, the a priori approach may be best; if one has hypotheses about specific factors that have special significance in adverse contexts (buffering), the interaction method may be preferred. Furthermore, if one aims to replicate analyses of psychological resilience across different data sets, this may be easiest to achieve with psychometric methods. In any case, we recommend that authors make explicit what the rationale is behind the choice of method given the research question and given the type of data that is available to them. When multiple approaches can be applied to the same research question and data, sensitivity analyses to critically assess the robustness of the results across different methods can be meaningful.

Often, it is also possible to combine different approaches in one study. For example, the a priori approach can be extended with additional statistical tests to examine whether the profiles of protective factors differ between levels of adversity, and the residual approach could similarly be stratified for levels of adversity. Furthermore, the a priori approach can be combined with longitudinal clustering approaches, in which specific trajectories of functioning rather than a single measurement of functioning can be regarded as "good outcomes." One could also ask whether DIORs (complex system approach) offer additive predictive value of a favorable response to a stressor to scores on a resilience scale. As we have shown in this chapter, each approach has strengths and weaknesses, suggesting that combining the strengths of multiple approaches in a single study could increase its validity.

Conclusion

Given the challenges associated with aging—from an individual as well as a societal perspective—research on resilience is vital to move the field of gerontology forward and improve the quality of life of older adults. Our review of six quantitative approaches shows that there are many ways to examine resilience in older adults. We encourage resilience researchers to review the different statistical possibilities, review their theoretical assumptions and strengths and limitations, and tailor their choice of quantitative approach to their specific research question and data. Furthermore, clearly reporting on these theoretical and methodological considerations for the choice of quantitative approach may help to build a theoretically

grounded empirical evidence base regarding the factors that contribute to resilience across a variety of adverse contexts and events, and provide maximal added value to what we already know about the general effects of risk factors on functioning in old age. Sensitivity analyses using an alternative approach may provide depth to the interpretation of the results from a specific quantitative approach. Finally, in addition to the approaches using "traditional" statistical methods such as scale construction and regression analysis, more recent advances such as latent class analysis and DIORs provide great potential for expanding scientific knowledge on resilience in old age.

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Positive Affect as Source of Resilience in Adulthood and Later Life

Anthony D. Ong, C. S. Bergeman, and M. Carrington Reid

> *Positively toned emotions serve three basic psychological functions in coping, namely, as breathers from stress, as sustainers of coping effort and commitment, and as restorers. To our knowledge, these functions, though features of everyday living, have neither been noted nor studied in research on human adaptation.*
>
> (Lazarus et al. 1980, p. 208).

Abstract In this chapter, we describe a program of research on resilience and aging from a developmental psychological perspective. We begin with a selective review of the broad literature on resilience, giving emphasis to the major approaches, empirical findings, and guiding principles that characterize prior studies. We then examine the relevance of positive affect as a basic building block of resilience in adulthood and later life. We put forth a dynamic conception of resilience to elucidate, theoretically and empirically, how some individuals are able to maintain, recover, or improve their health and well-being in the face of life challenges. Selected parts of ongoing studies are integrated to illustrate how our formulation of resilience guides our program of empirical research on positive affect and aging. We conclude with a brief consideration of future research directions to advance understanding of adulthood resilience.

A. D. Ong (✉)
Department of Human Development, Cornell University, Ithaca, NY, USA
e-mail: anthony.ong@cornell.edu

C. S. Bergeman
Department of Psychology, University of Notre Dame, Notre Dame, IN, USA

M. C. Reid
Division of Geriatrics, Weill Cornell Medical College, New York, NY, USA

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More than two decades ago, Lazarus et al. (1980) suggested that under intensely stressful conditions, positive affective states may provide an important psychological time-out, sustain continued coping efforts, and restore vital resources that have been depleted by stress. Until recently, there has been little empirical support for these ideas. Foundational evidence for the adaptive function of positive affect (PA) is beginning to accrue; however, this literature needs to be critically examined, integrated, and replicated. Multiple studies have now shown that the experience of PA has a wide range of effects on individuals (for reviews, see Lyubomirsky et al. 2005; Pressman et al. 2019; Steptoe 2019). Both theoretical and empirical work indicate that PA promotes flexibility in thinking and problem solving (Isen et al. 1987), counteracts the physiological effects of negative affect (NA) (Fredrickson and Levenson 1998), facilitates adaptive coping (Vedhara and Folkman 2000), builds enduring social resources (Keltner and Bonanno 1997), and sparks enhanced well-being (Fredrickson and Joiner 2002).

In this chapter, we describe select parts of ongoing studies to illustrate how previous conceptualizations of resilience have guided our program of empirical research on PA in adulthood and later life (Ong 2010; Ong et al. 2011b). Although this research involves multiple methods of data collection (i.e., longitudinal, diary, life history interviews) with a focus on families, communities, and other systems (see other chapters in this volume), the present review concentrates on psychological developments with a focus on the individual. Here, we highlight findings derived from the daily diary methodology used in our work. We summarize findings from this research to show the ways in which daily process approaches can be used to examine key issues about resilience and PA, as they unfold both within individuals and across everyday life circumstances. Finally, drawing on these findings, as well as relevant work by others, we discuss priority recommendations for future research.

Resilience: A Brief Historical Overview

Resilience has numerous meanings in prior research, but generally refers to the ability of individuals and communities to adapt successfully in the face of acute stress, trauma, or chronic adversity, and is manifested by sustainability or recovery of psychological well-being and physiological homeostasis (Luthar et al. 2000; Zautra et al. 2010). Underlying this notion are two fundamental conditions: (1) exposure to significant risks; and (2) evidence of positive adaptation despite serious threats to development. Historically, resilience research has been largely the purview of developmental investigators in the field of psychology dealing with early childhood and adolescence. In early investigations of childhood resilience (Garmezy et al. 1984; Rutter 1987), risk factors were defined as discrete experiences that carried high odds for maladjustment, such as parental psychopathology or community violence. In later work (Masten and Wright 1998), the concept of risk was broadened to include cumulative indices or tallies of adverse life events over time; acute trauma

and chronic life difficulties; and factors that statistically predicted later maladjustment in the general population (e.g., low birth weight).

Positive adaptation, the second core component of resilience, represents adaptation that is substantially better than would be expected given exposure to significant risk. Indicators of positive adaptation have varied across the context, population, and risk factor understudy (for a review, see Luthar 2006). Extant conceptualizations have, in general, included three kinds of phenomena: good developmental outcomes despite high risk, sustained competence under stress, and recovery from trauma (Masten et al. 1990). Under each of these conditions, researchers have focused their attention on identifying *protective factors* that served to modify the adverse effects of risks in a positive direction. On the basis of early reviews of the childhood and adolescence literature, Garmezy (1985) described three major categories of protective factors: *individual attributes* (e.g., an engaging "easy" temperament and good self-regulation skills), *relationships* (e.g., parental qualities with high trust, warmth, cohesion and close relationships with competent adults) and *external support systems* (e.g., quality neighborhoods and schools and connections to prosocial organizations). These set of protective factors have been remarkably reliable in predicting positive psychological functioning following adversity among children and adolescents (Garmezy 1987; Masten and Coatsworth 1998; Rutter 1987; Werner and Smith 1992). The consistent support for these assets and resources led Masten and colleagues to conclude that resilience emerges not from rare or extraordinary qualities and circumstances, but from "the everyday magic of ordinary, normative human resources in the minds, brains, and bodies of children, in their families and relationships, and in their communities" (Masten 2001, p. 201).

At the other end of the life-course is the literature on *optimal aging* (Baltes and Baltes 1990; Rowe and Kahn 1987; Schulz and Heckhausen 1996) that has delineated distinct patterns of developmental plasticity (i.e., changes in adaptive capacity) across multiple life domains. This work underscores distinctions between resilience as *recovery* from adversity, and resilience as *maintenance* of development in the face of cumulative risks (for a review, see Staudinger et al. 1995). Other research has conceptualized resilience as distinct from the process of recovery (Bonanno 2004). This perspective derives from studies demonstrating that resilience and recovery are distinct outcome trajectories that are empirically separable following highly aversive events such as interpersonal loss (e.g., Bonanno et al. 2002) and psychological trauma (e.g., Bonanno et al. 2006). Finally, several lines of adulthood research emphasize the need to assess positive outcomes (e.g., psychological well-being, developmental growth) in response to challenge (Cosco et al. 2018; Ryff and Singer 2003a; Ryff et al. 1998; Staudinger et al. 1993, 1995). Studies within this tradition have elaborated how age-graded influences (e.g., Baltes 1987; Ryff and Heidrich 1997), normative transitions (e.g., Smider et al. 1996), nonnormative events (e.g., Baltes et al. 1980; Tweed and Ryff 1991), and chronic life difficulties (e.g., Baltes and Baltes 1990; Singer and Ryff 1999) are linked to various aspects of adult mental and physical health.

Reviews of the research on child and adulthood/later life resilience (Bonanno 2005; Luthar and Brown 2007; Ryff and Singer 2003a) reveal notable parallels as

well as salient differences. Although an exhaustive review of the major differences and similarities across these two literatures is beyond the scope of this chapter, we briefly highlight convergent themes and guiding principles that shore up idiosyncratic viewpoints and approaches evident in prior work. From the perspective of human risk and vulnerability, it is noteworthy that extant studies of resilience have given limited empirical attention to the exact nature of the unique stressors and challenges confronting resilient children and adults. As Ryff and her colleagues note, in many instances, risk and vulnerability is inferred from aversive or otherwise unfavorable contexts (e.g., poverty, parental psychopathology, widowhood) rather than empirically assessed (Ryff et al. 1998). Likewise, within the developmental and adult literatures, most researchers agree that it is important to consider adaptive functioning more broadly, beyond just the avoidance of psychopathology or negative developmental outcomes (Masten et al. 1990; Ryff and Singer 2003a).

Both child and adult literatures (Bonanno 2004; Luthar and Brown 2007; Masten 2001; Ryff and Singer 2000) emphasize the need to assess the relative contribution of personality assets (e.g., psychological resilience, positive self-concepts, hardiness) and environmental resources (e.g., access to supportive relationships, close and nurturing family bonds, quality relationships within the community) in response to challenge. Finally, understanding of specific mechanisms and processes that underlie resilience is a central interest in both child and adulthood literatures (Luthar et al. 2000; Rutter 2000; Ryff and Singer 2003a; Ryff et al. 1998). That is, rather than simply studying which individual assets and social resources are associated with positive adaptation, there is growing awareness of the need to consider *how* such factors contribute to resilience in the face of challenge.

A Daily Process Approach to Studying Positive Affect

A primary goal of our research has been to investigate the daily context in which PA arises in response to challenge. Here we have adopted a daily process approach (i.e., diary methods) to examine how the nature of stressors and how the personality of those involved can affect the experience of PA in adulthood. This approach involves intensive, day-to-day monitoring of study variables, allowing us to view change in fluctuating processes, such as stress and PA, closer to their real-time moments of change. In addition to providing a framework in which to study inherently intraindividual (within-person) questions (Bolger et al. 2003), diary methods confer specific methodological advantages for the study of resilience and PA. As has been suggested by Almeida (2005), perhaps the primary advantage of this methodology is its ability to reveal dynamic processes (e.g., stress duration and recovery timing) that are of particular interest to resilience researchers. In addition, diary methods allow individuals to report their behavior and experiences over the range of potentially stressful circumstances encountered in everyday life, thereby facilitating ecologically valid research (Reis and Gable 2000). Finally, diary designs have the

potential for greater internal validity, because the shorter lag between experience and reporting minimizes memory distortions (Stone et al. 1999).

The emphasis on multiple pathways and multiple levels of analysis is prominent in recent reviews of both child and adulthood resilience (Luthar and Brown 2007; Lynch and Cicchetti 2002; Masten 2007; Ryff and Singer 2003b). In line with this research, we have embarked on the study of PA in everyday life by utilizing statistical methodologies that are responsive to complex, dynamic changes in adversity and resilience processes over time. A major strength of the analytic approaches that we utilize is the ability to model processes that may be simultaneously occurring within individuals and across contexts. These contemporary statistical approaches (e.g., multilevel modeling, dynamic systems analysis) have enabled us to address a variety of questions, including some that are difficult, if not impossible, to address with traditional cross-sectional methods. In particular, processes that involve patterns of change (e.g., cycles or rhythms), rate of change (e.g., duration or recovery), speed of change (e.g., nonlinear processes), and covariation in change (e.g., co-occurrence, lagged associations) are all ideally suited for study using multilevel modeling (MLM) and dynamic systems analysis.

Now that we have described the daily process paradigm, we turn our attention to three areas in which daily process studies have made contributions to the study of PA and adulthood resilience. The first pertains to having good health in face of daily stress and NA. The second pertains to maintaining good health and well-being despite the challenges of aging, including those that accompany the experience of chronic illness, such as chronic pain or functional limitations. The third pertains to resilience in the face of targeted life challenges such as loss of a spouse in older adulthood. Across each area, we summarize evidence for positive health and highlight protective influences of PA that account for salubrious outcomes. Guided by various theories and models of PA (Folkman et al. 1997; Fredrickson 2001; Pressman and Cohen 2005), we also highlight specific underlying mechanisms implicated in the protective influence of PA.

Positive Affect in the Context of Daily Stress and Negative Affect

Pressman and Cohen (2005) proposed the *stress-buffering* model of PA, which hypothesizes that PA may act as a *moderator*, attenuating the impact of stress on health. The stress-buffering model is consistent with the revised stress and coping theory (Folkman 1997b) and the broaden-and-build theory of positive emotions (Fredrickson 2001), which predict that stress-buffering is a byproduct of the coping, broadening, and building functions of PA, respectively. We have tested these predictions in our daily process research with older adults.

Ong and Bergeman (2004) tracked the daily lives of adults between the ages of 60 and 85 years over a 30-day period and found that the link between daily stress and NA was attenuated on days in which high levels of PA were also reported. Ong and Allaire (2005) extended these findings by examining whether daily experiences

of PA are important facilitators of adaptive recovery, quieting or *undoing* the autonomic short-term arousal generated by daily NA (Fredrickson and Levenson 1998). Although experiences of PA have been shown to suppress the cardiovascular aftereffects of NA in young adults (Fredrickson and Levenson 1998; Fredrickson et al. 2000), few studies have examined the cardiovascular effects of PA in older adults. This is an especially important gap in the literature given that the health effects of affective processes are thought to be most influential during the period surrounding late life, when biological vulnerability is greatest (Baltes et al. 1999). In our daily process investigation, healthy normotensive men and women underwent a 60-day diary assessment of NA, PA, and cardiovascular functioning. Affect, systolic blood pressure (SBP), and diastolic blood pressure (DBP) were assessed daily for 60 consecutive days. Results confirmed that the cardiovascular impact of daily PA was evident in the context of daily NA arousal. Taken together, these prior investigations suggest that PA may have both a protective and restorative function, *buffering* individuals from daily stress, as well as *undoing* the aftereffects of daily NA.

Positive Affect and Chronic Pain

Changes in physiological functioning pervade the aging process. Gradual declines in fundamental aspects of the immune, cardiovascular, and endocrine systems contribute to increased risks for morbidity and mortality. Importantly, alterations in physiological processes are not invariant with age, but are influenced by individual differences in vulnerability and resilience that accrue across the lifespan. Research on stress in older adults suggests that PA may play a key role in moderating the nature and intensity of chronic conditions that accompany aging processes (Ong et al. 2015).

We have studied the dynamics and individual differences underlying the experience of PA in adults with chronic pain. It is estimated that chronic pain afflicts between 50 and 80 million people in the United States alone, with an increased prevalence among the elderly (Gatchel 2004; Helme and Gibson 2001). Pain catastrophizing, defined as an exaggerated negative response to actual or anticipated pain, has been identified as one of the most robust and reliable predictors of the chronic pain experience (Sullivan 1995; Turk and Rudy 1992). Empirical evidence demonstrates that catastrophizing contributes to increased pain severity, disability, and emotional distress (for a review, see Sullivan et al. 2001a, b). Although much research has conceived of catastrophizing as an individual characteristic that remains highly stable over time (Keefe et al. 1989; Sullivan 1995), increasing evidence suggests that the magnitude of day-to-day variability in catastrophizing is much larger than is commonly expected (Holtzman and DeLongis 2007; Turner et al. 2004), implying that there may be important within- and between-person factors affecting the level of pain catastrophizing experienced over time.

One factor that may play an important role in fostering adaptive responses to pain and its attendant consequences is PA. Studies of emotional change in individu-

als experiencing chronic pain reveal that deficits in PA during episodes of severe pain are associated with increased vulnerability to emotional distress (Zautra et al. 2001b, 2004, 2005). One central tenet of Fredrickson's (2001) broaden-and-build theory of positive emotions is the *broaden* hypothesis. This hypothesis posits that PA broadens the scope of individual attention and thinking, widening the array of thoughts and action tendencies that come to mind (Fredrickson and Branigan 2001). Importantly, the cognitive broadening that accompanies positive affective states is thought to bolster the ways individuals resourcefully cope with stress (Fredrickson and Joiner 2002; Fredrickson et al. 2003). To the extent that PA serves to reduce the focus on NA, the broader hypothesis implies that PA should attenuate the cognitive narrowing engendered by pain catastrophizing. Although no studies have directly tested this prediction, indirect evidence consistent with the prediction can be drawn from studies showing that individuals with higher PA report greater broad-minded coping (Fredrickson and Joiner 2002; Vedhara and Folkman 2000), fewer ruminative thoughts (Koole et al. 1999; Lyubomirsky et al. 1998), and more positive appraisals of stress (Folkman and Moskowitz 2000; Tugade and Fredrickson 2004).

Ong et al. (2010) used a daily process design to examine the role of PA in the day-to-day experience of pain catastrophizing. A sample of 95 men and women with chronic pain completed daily reports of pain intensity, catastrophizing, and PA and NA every day for 14 consecutive days. Results indicated that beyond simply making people "feel good" (Fredrickson 2001), daily experiences of PA have the potential to counteract the narrow modes of habitual thinking (i.e., rumination, helplessness, magnification) characteristic of pain catastrophizing (Sullivan et al. 2001b), and thereby *broaden* and bolster people's cognitive resilience to subsequent pain (Zautra et al. 2005).

Positive Affect and Bereavement

Beyond the slings and arrows of daily stress and chronic illness, our work has also focused on the influence of PA amid targeted life challenges, such as the loss of a spouse. Few life events affect us more deeply than the loss of a spouse or life partner. Despite the emotional upheaval that the death of a loved one brings, however, there is substantial variability in peoples' responses to interpersonal loss. Some individuals experience acute and enduring psychological distress, while others do not. Although healthy adjustment to loss undoubtedly reflects differences in characteristics of the bereaved (e.g., developmental age, history of psychiatric illness; relationship history) and the loss experience itself (e.g., type, timing, intensity), growing empirical evidence also indicates that favorable outcome trajectories are sculpted by the capacity for PA (Keltner and Bonanno 1997; Moskowitz et al. 1996).

Perhaps one of the most surprising scientific discoveries to emerge from contemporary bereavement research is the finding that PA can co-occur with distress symptoms (e.g., anxiety, depression, subsyndromal PTSD), even in the midst of some of the most exigent of human experiences. In an early study examining the effects of

losing a child to sudden infant death syndrome (SIDS), Wortman and Silver (1987) found that bereaved parents reported at 3 weeks postloss experiencing feelings of happiness just as frequently as they experienced feelings of sadness, and at 3 months postloss reported experiencing PA with greater frequency than NA. Subsequent studies (Bonanno et al. 2005; Folkman 1997a; Moskowitz et al. 1996; Stein et al. 1997) have confirmed that PA can co-occur with distress symptoms among bereaved individuals, often with surprising regularity. In a study of AIDS-related caregiving and bereavement, for example, Folkman (1997a) reported that with the exception of the period immediately before and after their partner's death, the PA scores of men whose partners had died of AIDS did not reliably differ from their NA scores, and at 3 months postloss had returned to their pre-bereavement level.

Drawing on research on the dynamic model of affect (DMA) (Reich et al. 2003; Zautra et al. 2001a; b), Ong and colleagues (Ong et al. 2004, 2006) proposed that the capacity for PA engagement during times of stress may represent one potential pathway underlying flexible adaptation to loss. In contrast to other models of stress and coping, which view emotional adaptation entirely in terms of regulating psychological distress, the DMA takes into account both PA and NA in the stress process. The model predicts that under ordinary circumstances, PA and NA are relatively independent, whereas during stressful situations an inverse correlation between PA and NA increases sharply (for a review, see Reich et al. 2003). One implication of the DMA is that experiences of PA are more likely to diminish NA during times of elevated stress. The model also predicts that a relative deficit in PA should leave individuals more vulnerable to the effects of stress.

In an initial test of the DMA in the context of bereavement, Ong et al. (2006) explored how profiles of daily emotional responses intersected with the adaptive demands associated with conjugal loss. Recently bereaved widows completed reports of stress and affect each day for 98 consecutive days. In support of the DMA (Zautra et al. 2001a), significant reductions in the magnitude of the stress-NA correlation were observed on days in which greater PA was present. Furthermore, in lagged analyses, greater PA were predictive of the magnitude of next-day recovery, suggesting that PA may function in the service of well-being not only by interrupting the ongoing experience of stress during bereavement, but also by averting delays in adaptation to subsequent stressors (Fredrickson et al. 2003).

In addition, to attenuating stress responses, PA may also dampen physiological changes that accompany the bereavement process. Changes in multiple physiological systems (e.g., autonomic, immunological, neuroendocrine) occur during bereavement (see Buckley et al. 2012, Hall and Irwin 2001, Stroebe et al. 2007, for a review). Whereas the health consequences of loss are associated with altered biological responses (e.g., heightened adrenocortical activity, flattened diurnal cortisol rhythm), the available evidence suggests that physiological resilience in the wake of bereavement may be fueled by the experience and expression of PA. For example, Keltner and Bonanno (1997) showed that the occurrence of Duchenne or full-open mouth laughter was associated with greater decoupling of autonomic and verbal responses (i.e., heightened cardiovascular activity that is not accompanied by changes in self-rated NA), suggesting that expressions of PA that are genuine and

not merely ersatz may help to promote recovery following highly stressful life events such as the death of a spouse or partner.

Using prospective data from a national sample of adults, a study by Ong et al. (2011a) examined the extent to which pre- to post-loss changes in PA accounted for the impact of spousal loss on hypothalamic-pituitary-adrenal (HPA) axis function. Compared to a matched group of married individuals, bereaved individuals in this study showed a flattened diurnal cortisol slope, suggesting a dysregulation of the neuroendocrine system. The cortisol effects were robust and found to be statistically independent of a number of possible confounding factors, including age and socioeconomic status, personality, NA, and health behaviors. Importantly, however, the cortisol deficits associated with bereavement were fully mediated by reductions in PA, thus suggesting that waning PA plays a crucial role in the pathway leading from spousal loss to HPA dysfunction.

How Does Positive Affect Arise in the Face of Adversity?

Although much has been learned about the effects of PA in sustaining general health and well-being, less is known about the specific factors affecting the maintenance of PA within the context of stress and adversity. A number of protective characteristics or moderators may contribute to the tendency to experience PA in the face of stress. In this section, we briefly describe evidence for one such moderator, namely *psychological resilience*. Here again, we turn to our studies of everyday stress, chronic pain, and bereavement for clues regarding *who* benefits most from the protective benefits of PA.

In recent years, there has been increasing interest in the role that psychological resilience may play in supporting PA and fostering successful recovery from negative experiences like bereavement (Tugade et al. 2004; Waugh et al. 2008). Theoretical writings suggest that psychological resilience is a relatively stable personal dimension characterized by the ability to flexibly adapt to aversive circumstances (Block and Kremen 1996). Studies of diverse populations of adults have emphasized the inherent flexibility of psychological resilience: "Hardy" adults appear to be those who were committed to what they were doing, in control of their problems, and willing to accept changes in life as challenges to be mastered rather than threats to be endured (Kobasa 1979; Kobasa et al. 1982; Kobasa and Puccetti 1983; Maddi et al. 1987). Importantly, hardiness and psychological resilience have been hypothesized to benefit bereaved individuals through their buffering impact on loss-related stress (cf. Bonanno 2004; Maddi 2005).

Ong et al. (2010) found that higher levels of psychological resilience predicted a weaker association between PA and NA, and were linked to faster NA recovery from stress. In the Ong et al. (2006) study described earlier, among recently bereaved widows, higher psychological resilience was associated with attenuated reactivity to and recovery from daily stress. Moreover, the effect of psychological resilience on emotional recovery from stress was found to be transmitted through the experience

of PA (Ong et al. 2006). Thus, consistent with the notion that PA may serve as "breathers" from stressful encounters and "restorers" of depleted resources (Lazarus et al. 1980), these findings suggest that psychological resilience may help bereaved spouses sustain access to daily positive affective resources which, in turn, facilitate recovery from loss.

Although psychological resilience is assumed to capture a stable aspect of personality (Block and Kremen 1996), it is plausible that the suffering caused by aversive life events, such as the death of a spouse, may render people less flexible and therefore less resilient. Unfortunately, because most of the research on psychological resilience and serious adversity is conducted after the target event had occurred, it is impossible to rule out this possibility. Prospective data on psychological resilience obtained prior to the aversive event provide the only reliable means of addressing this issue (Bonanno et al. 2002). Findings from our prospective study of bereaved adults indicated compared with those with lower pre-loss psychological resilience, widowed persons with greater levels of pre-loss psychological resilience showed no significant declines in PA (Ong et al. 2011a).

These findings replicate and extend prior research in demonstrating the long-range consequences of psychological resilience for well-being (e.g., Kobasa et al. 1982) and for PA in particular (e.g., Fredrickson et al. 2003).Taken together, the data suggest that those with greater psychological resilience have a tendency to (a) experience PA even in the midst of significant challenge (e.g., chronic pain and bereavement) and (b) draw on such experiences to resourcefully rebound from stressful circumstances.

Methodological Challenges

In closing, we discuss a number of methodological challenges that seem especially important for sharpening our understanding of the role of PA in mental and physical health. First, of primary concern is the limited number of long-term longitudinal studies. Although a number of summative reviews have outlined theoretical pathways by which PA is related to health (Ong 2010; Pressman et al. 2019; Steptoe 2019), much of the empirical research to date on mechanisms has been cross-sectional, making it difficult to infer the causal significance of associations between PA and health. Overall, it is striking just how few studies have addressed the direction of influence. Prospective, multi-wave studies are critically important in advancing the science of PA and adulthood resilience because they (a) allow for tests of theoretical models of PA that assume stability and in the relations between PA and health over time; (b) help address questions regarding the time-scales (durations) on which sustained PA is associated with health outcomes; and (c) can provide evidence about the direction of causality.

Second, several investigators (e.g., Martin and Hofer 2004; Nesselroade 2001; Salthouse et al. 2006) have suggested that examining intraindividual variability constructs along interindividual differences dimensions can provide a rich source of

prediction. With few exceptions (e.g., Carstensen et al. 2011; Parrish et al. 2011; Piazza et al. 2013), however, longitudinal investigations that address the predictive utility of intraindividual variability have been absent in contemporary PA research. This contrasts with other areas of inquiry where, for example, short-term fluctuations in cognitive and sensorimotor functioning have been shown to be predictive of declines in fluid abilities (e.g., Li et al. 2001; Rabbitt et al. 2001), mild cognitive impairment (e.g., Bielak et al. 2010; Christensen et al. 2005), the onset of dementia (Hultsch et al. 2000), and early mortality (e.g., Eizenman et al. 1997; MacDonald et al. 2008). Beyond demonstrating that intraindividual variability is a distinct dimension, separate from mean level, along which individuals can be characterized, some have suggested that intraindividual variability concepts such as lability, plasticity, and homeostasis should be explicitly measured and integrated into extant theories of lifespan development and aging (see Nesselroade 2004).

Third, the relation among different facets of affective dynamics that act on different timescales – moment-to-moment and/or day-to-day and/or year-to-year – remains unresolved (Hollenstein 2015). In a recent study, Charles et al. (2015) demonstrated that age differences in daily NA were more pronounced when people recalled emotions over increasingly longer periods of time (e.g., across a month, a week, or a day). Furthermore, drawing on two measurement bursts of daily diary assessments across 10 years, Sliwinski and colleagues (2009) found that NA reactivity to daily stressors increased longitudinally and was stable across midlife. Nevertheless, NA reactivity varied within-persons, such that people were more reactive to daily stressors during times of higher global stress (Sliwinski et al. 2009). As the processes underlying fluctuations and changes in individuals' PA states may be different than for NA, determining the timescale(s) on which PA actually operates and the contexts underlying within-person variation in PA dynamics may be crucial to resolving divergent findings in the literature (Houben et al. 2015). Likewise, measures of health may reflect different processes when captured at different timescales. For example, transient increases in inflammatory activity are appropriate and adaptive in the face of immediate threat, whereas persistent inflammation is indicative of physiological dysregulation. Given that the timescale that is appropriate for capturing affective and health processes will depend on the research question, a major challenge for future research on affect dynamics is to account for temporal complexity by examining affect dynamics and health at multiple timescales, simultaneously. For example, findings from middle-aged samples indicate that daily PA tracks with across-day or day-to-day fluctuations in biological and behavioral health indicators, including diurnal cortisol and sleep (Ong et al. 2017; Sin et al. 2017a, b). Given that PA can fluctuate rather quickly, the cadence of assessment for moment-to-moment tracking of PA will be a fruitful avenue for future research.

A fourth methodological drawback concerns inadequate assessment of potential alternative explanations for why high levels of PA may confer favorable health. Specifically, there is no consensus regarding which negative psychological states to measure and control for in studies linking PA to health (Boehm and Kubzansky 2012). Past research has adjusted for various constructs, such as general NA, spe-

cific negative affective states, and depressive symptoms. Given that NA may covary with PA (Reich et al. 2003), attention to potential confounding by negative arousal states is critical. For researchers interested in affect dynamics, for example, a critical methodological issue is whether relations between measures of PA dynamics (e.g., variability, instability, inertia, reactivity) are independent of measures of NA dynamics (Ong et al. 2013; Ong and Ram 2017; Sin et al. 2015).

A fifth methodological challenge concerns the measurement of PA itself. In particular, the vast majority of studies rely on self-report measures. It is possible that self-report measures of trait and state PA contain adjectives (e.g., vigor, energetic, alert) that are confounded with physical health (Pressman and Cohen 2005). This concern might be addressed in future work by eliminating overlap between the putative measure of PA and the putative health outcome or by including objective measures of physical health. Measuring PA using implicit measures that assess automatic processes operating outside of conscious awareness (Quirin et al. 2009a, b) could add to our understanding of individual differences in PA. Specifically, discrepancies between high explicit PA and low implicit or nonconscious PA may capture another potential form of fragile PA (Ong and Ram 2017). The use of diverse modes of PA assessments (e.g., informant reports, behavioral assessments, coding of facial expressions) may help address these concerns, as well as reducing reporting biases (Diener et al. 1991).

Sixth, studies of resilience and aging are highly relevant to health disparities research, wherein a number of paradoxical findings have been reported. For example, minority aging individuals may be especially vulnerable to stress in late life due to the double burden of cumulative disadvantage (Dannefer 2003) and minority status (Ferraro and Farmer 1996). However, disadvantaged minority older adults who survive to late life may be particularly resilient (Brown et al. 2012). Other research, primarily in young adults, suggests that for some minority youth, adaptive behavior profiles are accompanied by maladaptive physiological profiles, a phenomenon referred to as "skin-deep resilience" (Brody et al. 2013). Future research will need to determine the extent to minority health in later life is characterized by a healthy survival effect, double jeopardy, or skin-deep resilience. In general, the intersections between minority status, discrimination, and well-being remain grossly understudied (Ong and Burrow 2018; Ong and Edwards 2008; Ryff et al. 2003). This is a fertile area of aging research that opens up possibilities from multiple disciplines including economics, sociology, psychology, and epidemiology.

Finally, in view of accumulated evidence, there is a need for effective interventions that target vulnerable older adults, such as those suffering from chronic pain. Although there is increasing interest in the use of evidence-based nonpharmacological approaches to managing chronic pain (Chang et al. 2015; Niknejad et al. 2018; Reid et al. 2008), standard behavioral therapies for chronic pain, such as cognitive-behavioral therapy (CBT) and mindfulness-based stress reduction (MBSR), typically focus on targeting negative affective states (e.g., anxiety and depression) (Keefe et al. 2001; Koechlin et al. 2018) and yield only modest treatment effects (Eccleston et al. 2013; Garcıa-Campayo et al. 2008). Efforts are therefore needed to develop more effective psychological treatments for chronic pain by

identifying new targets for intervention. Multicomponent interventions that specifically target PA-enhancing mechanisms (e.g., broadening the scope of attention, promoting positive reappraisal of stressors; enhancing savoring of valued activities) hold great promise for not only alleviating distress, but also improving well-being and physical health among vulnerable populations (Finan and Garland 2015; Moskowitz et al. 2012, 2017).

Conclusion

We began this chapter by underscoring how little we know about the nature of PA and health in later adulthood. In his book *Outliers* (2008), writer Malcolm Gladwell sums up the idea with the observation:

> Biologists often talk about the "ecology" of an organism: the tallest oak in the forest is the tallest not just because it grew from the hardiest acorn; it is the tallest also because no other tree blocked its sunlight, the soil around it was deep and rich, no rabbit chewed though its bark as a sapling, and no lumberjack cut it down before it matured. We all know that successful people come from hardy trees. But do we know enough about the sunlight that warmed them, the soil in which they put down the roots, and the rabbits and lumberjacks they were lucky enough to avoid?

In this chapter, we have described a program of research, the results of which collectively evoke the metaphor that resilience is not about trees. It's about forests. This research has yielded important clues about the nature of daily resilience as it unfolds in real life. A major objective of this research has focused on the role of PA as one important mechanism underlying resilient adaptation. Our efforts to date have largely explored the degree to which PA may serve as a bulwark against the normal disruptions and setbacks of day-to-day life, in particular, the pangs of chronic illness and loss. We have argued that PA represents a "basic building block" of resilience and may have demonstrably beneficial effects when present during times of stress.

When we look at the problem in a multivariate way, we do not find a single, simple answer to the question of how PA influences health. Instead, our findings suggest that the experience of PA is generative of multiple assets, catalyzing or setting into motion a cascade of processes, such as *buffering*, *broadening*, and *undoing*. The consequences of these processes increase the need to translate our understanding of basic research into effective interventions that target older adults, their families, and surrounding communities. Detailed analyses of these and other variables will surely deepen our understanding of the resilience process. The time for such inquiry is at hand.

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Psychological Resilience in the Face of Later-Life Spousal Bereavement

Deborah Carr

Abstract This chapter draws on stress and coping perspectives to document the contextual, relational, and personal characteristics associated with psychological resilience following late-life spousal loss. It highlights how social/structural and developmental factors are linked with older bereaved spouses' high levels of resilience relative to their younger counterparts. The chapter synthesizes research on psychological adaptation to late-life spousal loss, highlighting factors that distinguish those who withstand or bounce back emotionally, relative to those who suffer from intense or sustained distress. Potentially modifiable aspects of the death and structural factors linked to resilience are highlighted in an effort to challenge notions that resilience is a trait-like feature of the individual alone. The chapter concludes by identifying avenues for future research.

Keywords Psychological resilience · Older adults · Widowhood · Stress and coping · Adaptation

Stress is an inevitable part of life, including in old age. Early studies posited that stress—defined as any significant change in one's social environment, whether positive (e.g., a new grandchild) or negative (e.g., death of a spouse)—could overwhelm one's coping capacities, and render one vulnerable to poor physical and mental health (Holmes and Rahe 1967; Selye 1956). Bereavement, especially the death of a spouse, is common in later life and is considered among the most stressful and emotionally devastating life events (Holmes and Rahe 1967). Classic theoretical writings, rooted in psychoanalytic and attachment theories, characterized the loss of an intimate personal relationship as uniformly distressing (Middleton et al. 1993). As such, bereaved persons who did not show symptoms of sadness, grief, or depression (i.e., absent grief) or who continued to carry out their daily activities, seemingly unaffected by the loss, were diagnosed as in denial, pathological, "inhibited," or incapable of healthy emotional attachments (Deutsch 1937; Middleton et al. 1993; Parkes 1985).

D. Carr (✉)
Department of Sociology, Boston University, Boston, MA, USA
e-mail: carrds@bu.edu

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In stark contrast, contemporary empirical research challenges the notion that persons who withstand close personal loss seemingly unscathed are "pathological" (e.g., Bonanno 2004; Bonanno et al. 2001, 2002). Prospective studies of bereavement show that resilience is the norm, where resilience broadly encompasses the capacity to "withstand or recover quickly from difficult conditions" (Fletcher and Sarkar 2013). Resilience is a multifaceted construct, without a universally agreed upon definition, measure, or "gold standard" (Windle et al. 2011). It has been operationalized as a set of personal traits that enable one to adapt to adversity, such as perseverance, self-reliance, good humor, and equanimity (King et al. 2019). Resilience also has been characterized as the dynamic process of managing, adapting to, or overcoming adversity, with an emphasis on the specific actions one takes, such as seeking out and activating social (e.g., personal relationships) and nonsocial (e.g., financial) resources (Schafer et al. 2009).

For bereavement researchers, resilience generally refers to a psychological reaction to loss distinguished by few, mild, or short-lived depressive and grief symptoms (Bonanno 2009; Infurna and Luthar 2017). In stark contrast to early theoretical writings that described absent grief as "pathological," contemporary empirical studies generally show that resilience is the norm, especially in the face of later-life spousal loss. Just one-third of older widows and widowers experience symptoms of grief and sadness that persist for up to 18 months (Bonanno 2004; Bonanno et al. 2002), and an even smaller proportion (15 percent) experience complicated or chronic grief (Prigerson et al. 2008; Shear et al. 2011). Whether one is psychologically resilient or vulnerable following loss is shaped, in part, by enduring personal characteristics like perseverance (King et al. 2019) and personality traits like extraversion and conscientiousness (Pai and Carr 2010). Yet contemporary bereavement research has moved beyond individual-level traits to also explore the dyadic (e.g., marital quality) and structural factors (e.g., death context) as well as the material and nonmaterial coping resources that help bereaved older adults to "bounce back" from loss-related psychological distress.

This chapter draws on stress and coping perspectives to document the contextual, relational, and personal characteristics associated with psychological resilience following late-life spousal loss. First, the core themes of stress and coping models are reviewed, which describe how particular subtypes of stress may undermine psychological well-being, and the coping resources that facilitate resilience. Second, the ways in which both social/structural and developmental factors are linked with older bereaved spouses' high levels of resilience relative to their younger counterparts are examined. Third, research on psychological adaptation to late-life spousal loss is synthesized in order to highlight the principal factors that distinguish those who withstand or bounce back emotionally, relative to those who suffer from intense or sustained distress. Fourth, potentially modifiable aspects of the death or structural factors linked to resilience are identified in an effort to challenge notions that resilience is a trait-like feature of the individual alone. Finally, avenues for future research that can advance our understanding of resilience, stress, and coping in old age are discussed.

Stress and Coping: An Overview

Stress and Its Subtypes

Stress, or a stressor, refers to any environmental, social, biological, or psychological demand that requires a person to adjust their usual patterns of behavior. Early research was conducted on animals, where stress was conceptualized as exposure to noxious environmental stimuli, such as extreme temperature (Selye 1956). Since that time, stress research has evolved to focus on psychosocial stressors affecting humans (Holmes and Rahe 1967; Wheaton 1990). The term "stress" is often used broadly and indiscriminately, yet it encompasses several distinctive subtypes, which are critical to understanding resilience because each differs with respect to their intensity, time course, and duration. The three main subtypes are life events, chronic strains, and daily hassles.

Life events are acute changes that require adjustments within a relatively short time period, such as the death of a spouse. The psychological impact of a stressful life event depends on its magnitude, undesirability, expectedness, and timing, where events that are major, unwanted, unexpected (e.g., sudden death of spouse) or that happen "off-time" (e.g., being widowed prematurely) are particularly distressing (George 1999). While early perspectives characterized all disruptive life events as distressing (Holmes and Rahe 1967), contemporary research finds that the psychological impact of an event is contingent on one's "role history" (Wheaton 1990), or qualitative aspects of the role one is exiting or entering. For instance, death of a spouse following a long period of caregiving and witnessing a partner's suffering may be met with relief and rapid "bouncing back" rather than distress (Keene and Prokos 2008). Conversely, the loss of a particularly salient and satisfying role, such a high-quality marriage may especially compromise well-being (Carr et al. 2000; Schaan 2013). Life events are not monolithic, thus the extent to which a person is psychologically resilient versus vulnerable in their aftermath may be a function of the event's properties (Hu et al. 2015).

Chronic strains are persistent and recurring demands that require adaptation over sustained periods, such as intensive caregiving, managing one's own chronic conditions, or witnessing a spouse's battle with Alzheimer's disease (e.g., Schulz and Martire 2004; Shih and Simon 2008). Given their ongoing nature, chronic strains are generally found to be more powerful predictors of psychological well-being than acute events (Avison and Turner 1988; Turner et al. 1995). Daily hassles are minor events and occurrences that require adjustment throughout the day, such as an argument with a paid caregiver, or an unproductive telephone call with one's health insurer (Hahn et al. 2013; Lazarus and Folkman 1984). Historically, most stress research has focused on life events and chronic stressors, although in recent years the collection of daily diary data as a component of population-based surveys has generated interest in daily strains (Almeida 2005). The emotional effects of daily hassles are generally found to dissipate in a day or two (Bolger et al. 1989). However,

daily hassles that accumulate and recur over long time periods can intensify emotional distress (Bolger et al. 1989).

These three subtypes of stressors often are treated analytically as separate experiences. For instance, studies of psychological resilience following spousal loss historically have focused on a dichotomous indicator of widowhood status without attention to the role history, context, or secondary strains that occur following the death (McCrae and Costa Jr 1988). However, stressors rarely occur in isolation from one another. The extent to which stressors co-occur or accumulate are consequential for one's psychological resilience or vulnerability, and the failure to consider this larger stress context may lead to an over- (or under-) estimation of psychological resilience (or vulnerability). A discrete life event may create subsequent chronic strains (e.g., death of one's spouse may create financial insecurity), or chronic strains may give rise to a stressful life event (e.g., dementia caregiving may precede placing one's spouse in an assisted living facility). These patterns are referred to as stress proliferation, or the "process that places people exposed to a serious adversity at risk for later exposure to additional adversities" (Pearlin et al. 2005, p. 205). Difficulties that occur before, alongside, or following a single stressor may be the hardest to bounce back from, given compelling research showing that cumulative stress undermines one's capacity to cope more than single or isolated stressors, and that ongoing chronic stressors are generally more difficult to withstand than single events (Kendler et al. 1998, 1999; Kessler 1997). However, until recently, most resilience research has focused on adaptation following a discrete event rather than trajectories of chronic, acute, and quotidian adversities (Schetter and Dolbier 2011). Thus, resilience research requires a careful consideration of the nuanced and heterogeneous nature of stressors linked with psychological adaptation.

Coping Resources

A second integral component of research on psychological resilience is an understanding of coping strategies and resources. Coping strategies encompass "cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person" (Lazarus and Folkman 1984, p. 141). Researchers have identified two broad strategies for coping with stress: problem-focused coping (PFC) seeks to alter or eliminate the stressful situation, whereas emotion-focus coping (EFC) is aimed at adjusting one's emotional or cognitive response to the stressor. PFC may promote psychological resilience by improving the conditions that are a source of distress (Folkman and Moskowitz 2004). However, in situations that cannot be altered, managing one's emotional reactions may be a more viable and protective pathway to resilience; no amount of PFC will bring back a deceased spouse. EFC encompasses avoidant strategies like denial and substance use, and approach strategies like seeking emotional support, cognitive reframing (i.e., thinking positive thoughts), or turning to a higher power (Nielsen and Knardhal 2014). Avoidant EFC strategies like blocking out

troubling thoughts generally undermine psychological resilience (Folkman and Moskowitz 2004; Taylor and Stanton 2007).

The extent to which one is resilient or vulnerable to stress also varies on the basis of one's coping resources, or the material, psychological, and interpersonal resources one can draw on in difficult times (Bisconti et al. 2006; Pearlin et al. 2005). Social support, or the instrumental, emotional, and informational assistance upon which one relies when faced with stress, is essential to psychological resilience, a theme revisited later in this chapter (Ozbay et al. 2007; Thoits 2010). However, both coping style and resources are not solely an attribute of the individual, and instead reflect structural factors. For example, women, ethnic and racial minorities, and persons with lower levels of education may be less likely to use problem-focused coping, both because they have a lower sense of perceived mastery and because they tend to have fewer economic resources necessary for making situational changes (Thoits 1995; Turner and Roszell 1994). Conversely, women typically report more social and emotional support from friends and children than do men, and blacks report more support from their religious community relative to whites (Antonucci 1990; Shorter-Gooden 2004). Thus, understanding resilience among bereaved older spouses requires attention both to structural and personal factors that enable some to bounce back psychologically, whereas others succumb to longer-term mental health decrements.

Psychological Resilience Among Older Widowers

Psychological resilience is now regarded as the norm rather than the exception among older bereaved spouses in the contemporary United States (Bonanno et al. 2002; McCrae and Costa Jr 1988; Ong et al. 2006; Sasson and Umberson 2014). For example, Bonanno et al. (2002) tracked a sample of married persons ages 65+ through the widowhood transition, and documented their symptoms of depression and grief from up to 3 years pre-loss through follow-ups six and 18 months post-loss. They documented five distinctive trajectories of psychological symptoms, as shown in Fig. 1. The most common trajectory was resilient, accounting for 46 percent of the sample. This profile included persons with very few or no symptoms of depression both pre- and post-loss, where depressive symptoms were measured with the Center for Epidemiological Studies depressive symptoms scale (CESD; Radloff 1977). Persons in the resilient category appeared to withstand both spousal death and the period prior to the loss without psychological symptoms. By contrast, persons in the common-grief category (12 percent) evidenced trajectories consistent with definitions of resilience that encompass "bouncing back" from a stressor; these men and women experienced a sizeable increase in depressive symptoms in the first six-months post-loss, but then returned to pre-loss levels one year later. These two categories, which exemplify the two main subtypes of resilience ("withstanding," and "bouncing back") accounted for well over half of the sample. Parallel studies in Europe yielded similar results, with a prospective study of older bereaved spouses

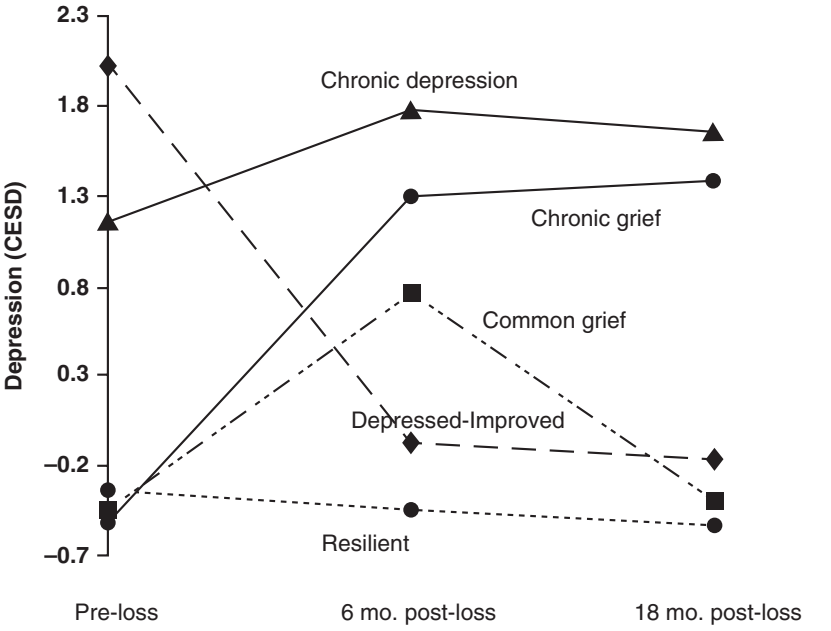

Fig. 1 Patterns of depression (Center for Epidemiologic Studies Depression [CES-D] scores) from pre-loss to 18-months post-loss ($N = 185$)
Source: Bonanno, G.A., Wortman, C.B., Lehman, D.R., Tweed, R.G., Haring, M., Sonnega, et al. (2002). Resilience to loss and chronic grief: A prospective study from pre-loss to 18-months post-loss. *Journal of Personality and Social Psychology, 83(5)*, 1150–1164

in Switzerland classifying 54 percent of respondents as "resilient" (Spahni et al. 2015).

Trajectories of intense or persistent symptoms are far less common. Bonanno et al. (2002) identified two such categories among US elders, accounting for one-quarter of their sample, whereas Spahni et al. (2015) found that vulnerable persons accounted for just 7 percent of their Swiss sample. Bonanno and colleagues found that bereaved persons in the chronic grief (16 percent) and chronic depressed (8 percent) categories evidenced symptom trajectories consistent with classic conceptualizations of bereavement, where survivors experience intense symptoms of sadness and distress which persist over considerable periods of time (Middleton et al. 1993). They also identified a depressed-improved trajectory (10 percent), a small yet important category that underscores the importance of considering role histories when studying resilience among bereaved spouses (Wheaton 1990). These persons reported very high levels of depressive symptoms prior to loss, but then experienced a dramatic drop in symptoms after the death, at which time their psychological profile resembled that of "resilient" persons. A study that used data points from the post-loss periods only would have generated a portrait of older adults, who were seemingly untouched emotionally by the loss. However, the use of multiple data waves reveals that, for some bereaved spouses, what appears to be "resilience" is

actually a response to an improvement in one's situation, such that the distress associated with spousal caregiving and witnessing an ill spouse's suffering has come to an end (Bonanno 2004; Bonanno et al. 2002; Carr et al. 2001; Galatzer-Levy and Bonanno 2012).

Understanding the factors linked to psychological resilience (versus vulnerability) following spousal loss is an important goal, as it informs the development of interventions and practices to improve and sustain older widowed persons' well-being. Next, I highlight exemplar individual-level, dyadic, and contextual factors that are linked with bereaved elders' psychological resilience. A full review of risk and resilience factors is beyond the scope of this chapter (for a review, see Carr and Mooney 2021); rather, I have selected a subset of influences, to show how resilience is powerfully shaped by attributes of the stressor, including its timing, role history, and related strains that have either given rise to or emanate from the primary stressor of widowhood.

Age and Bereaved Spouses' Resilience

The extent to which one is psychologically resilient following spousal loss varies on the basis of age, with most research concluding that older adults are more likely than their younger counterparts to "bounce back" or show only modest symptoms of distress. Yet this evidence reveals that it is not chronological age per se that is linked with resilience, but rather the context of loss and proliferation of post-loss challenges that typically befall older versus younger bereaved persons. As such, failure to consider these contextual factors may yield a misleading portrait of widowed persons' psychological resilience.

Researchers have pinpointed several reasons for older widow(er)s' resilience relative to their younger counterparts. First, older adults are more likely than midlife or younger adults to have experienced other familial deaths, including deaths of parents, siblings, and adult children (Umberson et al. 2017). Experiences of loss that accumulate over the life course contribute to the development of wisdom (Bluck and Glück 2004; Linley 2003). Wisdom has been described as "expert knowledge in the domain fundamental pragmatics of life" that is acquired by those who are "willing… to learn from life's lessons and to be transformed in the process" (Ardelt 2004). This hard-earned knowledge, in turn, may help older adults respond to adversity with equanimity, acceptance, a sense of meaning, and resilience (Ardelt and Jeste 2018; Carnelley et al. 1999).

Second, at older ages, spousal loss is recognized as a "normal" transition that happens at the end of a long and (ideally) fulling life together (Hansson and Stroebe 2007). This is consistent with research on stressful life events, more generally, which shows that transitions that occur "on time" are less distressing than those that happen prematurely or out of sync with one's peers (George 1999). For older women, in particular, widowhood is a normative transition. In the United States, in 2016, 34 percent of women ages 65+ and fully 72 percent of women ages 85+ were

currently widowed, compared to 13 and 35 percent of men, respectively (U.S. Census Bureau 2016). Older women may anticipate and prepare for this transition as they observe their peers experiencing widowhood (Fooken 1985; Neugarten and Hagestad 1976), and may seek emotional and informational support from their widowed peers (Silverman 2004). For these reasons, persons widowed prematurely experience more intense and more persistent symptoms of distress than those widowed later in life (Sasson and Umberson 2014). Some intriguing new research suggests that persons married to a considerably older spouse fare worse emotionally than their counterparts in age-homogamous unions upon spousal loss, in part because they are making the widowhood transition prematurely (Choi and Vasunilashorn 2014).

Third, most later-life deaths occur at the end of a long-term chronic illness, with most older adults suffering from multiple comorbidities that have compromised their daily well-being (Nunes et al. 2016). Consequently, for most older adults, a spouse's death is not only anticipated but might come as a relief from witnessing their dying partner's suffering over a protracted time period (Carr et al. 2001). Nine of the ten leading causes of death among persons ages 65+ in the United States in 2017 were chronic illnesses, including heart disease, cancer, lung disease, and Alzheimer's disease; chronic illnesses are typically associated with discomfort, difficulty breathing, complex medication regimens, and a need for personal care. In contrast, unanticipated and violent deaths including illness/injury, homicide, and suicide are far more common in young and middle adulthood. While cancer and heart disease are the two leading causes of death among midlife adults ages 45–64, unintentional injury was the third most common cause of death in that age group, and was the first most common cause of death in all younger age groups (Centers for Disease Control and Prevention 2019). Given that accidental and violent deaths are linked with particularly severe and long-term psychological symptoms, including anger, post-traumatic stress disorder (PTSD), and complicated grief, the late spouse's health conditions are an important mechanism contributing to age differences in bereaved spouses' psychological resilience (Kaltman and Bonanno 2003; Krychiw et al. 2018; Tal et al. 2017). This research is consistent with stress and coping theories which underscore that the psychological impact of a stressful transition is conditional upon one's role history (Wheaton 1990).

Fourth, spousal deaths trigger different secondary stressors or "stress proliferation" for older versus younger adults. The death of a working-age spouse (especially if that spouse was the family's primary breadwinner) may threaten one's financial security and stability, which can further undermine one's psychological well-being (Hurd and Wise 1989; Siflinger 2017). For married couples with minor children living in the home, spousal death brings the additional stress of single parenthood (Gass-Sternas 1994) and the adjustments required upon remarriage or forming a new cohabiting union (Bishop and Cain 2003). Older widow(er)s, by contrast, are less prone to decrements to their economic standard of living upon loss, because most were married to a retired person and rely on pensions rather than work-related income as their primary source of income (Center on Budget and Policy Priorities 2019). In the United States, Social Security is the main source of income security

for older adults; widowed persons are entitled to 100 percent of their late spouse's benefits if they are greater than the benefits one would have received from their own worker benefits. Older widowed persons, especially women, have very low rates of remarriage and tend to have grown children who live on their own, and thus are less likely than younger widowed persons to experience stressors related to childcare and forming new families (Livingston 2014).

Fifth, some research suggests that the boundaries demarcating "his" and "her" roles in heterosexual marriage become blurred as husbands and wives age, retire, and face health declines. As such, the secondary strains of taking on new and unfamiliar household tasks post-loss may be mitigated for older adults, helping the surviving spouse to withstand the loss with modest or only short-lived symptoms of anxiety or sadness. Although older married couples abide by a gender-typed division of household labor just as younger couples do, this division changes upon retirement, as spouses take on more gender-equitable roles (Leopold and Skopek 2015). Household roles also shift and converge as older adults experience health declines and functional limitations. Physical health problems may render older adults less able to perform the homemaking or home maintenance tasks they did earlier in life. For instance, if a wife's physical limitations prevent her from preparing meals, her husband may take over those duties. Likewise, a husband's cognitive decline may result in a wife's increased involvement in financial decisions that previously were managed by the husband. Older adults may gradually take on their ailing spouses' tasks prior to widowhood, and thus they may be better prepared for the death (Carr 2004a; Roberto et al. 2013). Managing the practical tasks of everyday life that were once managed by their late spouse is a key component of coping, and can contribute to the emotional resilience of recently bereaved older adults (Stroebe and Schut 2016).

Taken together, this research demonstrates that the capacity to survive spousal loss with few or short-lived symptoms is influenced by contextual factors and secondary stressors linked with later-life deaths and bereavements. However, age-related cognitive and emotional factors also have been implicated in older widowed persons' psychological resilience, including age-related declines in emotional reactivity (Charles and Carstensen 2007). Compared to younger adults, older adults have a greater capacity to manage or "regulate" their emotional states (see Ong and Löckenhoff 2016 for review). As such, they report less extreme levels of both positive and negative affect, and less variability in their emotional responses to stress—a key attribute of resilience (Gaitz and Scott 1972; Mroczek and Kolarz 1998; Stacey and Gatz 1991). Consequently, their grief reactions are less intense and shorter lived compared to younger bereaved spouses (Nolen-Hoeksema and Ahrens 2002; Sanders 1993; Sherbourne et al. 1992). Emotional reactivity declines in later life because of several factors, including a biological decrease in autonomic arousal; the greater habituation of older adults to stressful life events; and shifts in the relative salience of emotion versus cognition in late life (Carstensen and Turk-Charles 1994; Diener et al. 1985).

Role History: The Quality of the Late Marriage

Although older adults generally show fewer and shorter-lived symptoms of depression and grief following spousal loss, relative to younger persons, research still documents stark variation in the psychological symptoms experienced by older adults. One important influence is the nature of the relationship they have lost; as stress theories posit, the loss of a relationship that was close-knit and loving may be more difficult to bounce back from than the loss of a relationship that was distant or conflictual (Wheaton 1990).

Early theoretical writings suggested two distinct and competing hypotheses regarding the link between relationship quality and bereaved spouses' resilience. Psychoanalytic models suggested that bereaved persons with the most troubled marriages would experience intense and prolonged grief (Parkes 1985). This perspective held that persons who had conflicted marriages would find it hard to let go of their spouses, yet also feel angry at the deceased for abandoning them. However, empirical studies have found little support for this hypothesis, instead confirming a core theme of attachment theories: that the most close-knit relationships are mourned most strongly (Bowlby 1980). Longitudinal studies that track married persons over time through the widowhood transition have been especially effective in documenting the ways that marital quality affects psychological reactions to loss. These studies have found that older persons whose marriages were marked by high levels of warmth and dependence, and low levels of conflict, experience elevated grief symptoms within the first 6 months post-loss (Bonanno et al. 2002; Carr et al. 2000; see also Futterman et al. 1990).

However, when a longer-term view is adopted, researchers have found that close ties with one's late spouse are a source of psychological resilience, as widow(er)s draw strength from continuing bonds with their late spouse. Early work on grief suggested that bereaved persons needed to dissolve or relinquish their emotional ties to the deceased and get on with their lives (e.g., Freud 1917/1957), yet current research on "continuing bonds" suggests that maintaining an emotional tie to the deceased is an integral part of healthy adaptation. Although some aspects of continuing bonds may inhibit resilience in the early stages of loss (e.g., not engaging with new relationships and activities), maintaining ties can be helpful, uplifting, and a source of recovery, especially as time elapses since the loss (Field 2008). Widow(er)s may ponder what their late spouse might do when faced with a difficult decision, or may keep their spouse's memory and legacy alive by recognizing their continuing positive influence on one's current life. The warmth and closeness of the relationship may thus provide an emotional boost and affirmation in the longer-term after the death (Klass and Steffen 2017).

Coping Resources: Emotional and Instrumental Support

Stress and coping perspectives underscore the importance of social support as an essential resource for adapting to spousal loss. The emotional support, practical assistance, and useful information provided by family and friends is critical to older bereaved spouse's psychological resilience, while the lack of these resources—most notably, social isolation—undermines one's emotional recovery from loss. Close relationships with family and friends are the main source of practical and emotional support for widow(er)s, and are a key reason for why older widows tend to be more emotionally resilient than widowers, and black bereaved spouses fare better than white widow(er)s (Carr 2004a, b; Lee and DeMaris 2007). Women maintain closer relationships with family and friends over the life course than their male counterparts; as such they receive more practical and emotional support from their children and friends post-loss than do widowers (Carr and Moorman 2011). Women also have larger and more varied friendship networks than men, and these friendships are an important source of emotional uplift as widows cope with spousal loss (Ha 2008). African American bereaved spouses report more support from their children and members of their religious communities relative to whites, which accounts in part for their more modest and shorter-lived symptoms of distress and despair post-loss (Carr 2004a, b).

The specific types of support received also are consequential for bereaved spouses' psychological resilience, with some studies suggesting that emotional support is more critical than instrumental support (Bankoff 1983; Bisconti et al. 2006). These results are consistent with the core themes of problem—and emotion—focused coping research, which suggest that the latter may be a more effective path to resilience when the stress context cannot be altered. In the case of spousal loss, where the adversity is permanent and irreversible, the receipt of practical support may do little to lessen the pain. Rather, bereaved spouses may be better assisted through the receipt of informal emotional support that soothes their negative emotions (Powers et al. 2014). More intensive support, including professional help, does not boost resilience and is not required by most bereaved persons, other than a small fraction for whom prolonged grief symptoms are a byproduct of longstanding and underlying depression (e.g., Bonanno et al. 2002).

Stress Proliferation: The Context of the Death

When, where, and under what conditions one's spouse dies shapes the bereavement experiences of the surviving spouse. Anticipated deaths tend to be less distressing than sudden or unanticipated ones; one prospective study found that spouses who experienced sudden bereavement had elevated symptoms of depression six months after the death, whereas those who anticipated the death revealed greater psychological resilience (Burton et al. 2007; see also Sasson and Umberson 2014). The

knowledge that one's partner is going to die in the imminent future provides the couple time to address unresolved emotional, financial, and practical issues before the death. This preparation for death enables a smoother transition to widowhood, and a greater capacity to bounce back quickly from the stress of the loss. However, anticipated deaths are not uniformly 'easier' for older persons; their impact is contingent on other co-occurring stressors, consistent with stress and coping models. For example, anticipated deaths often are accompanied by a spouse's long-term illness, pain and suffering, intensive caregiving, and neglect of one's own health concerns, thus taking a toll on one's health (Carr et al. 2001) and leaving one socially isolated (Burton et al. 2007). Decrements in one's own physical health and social isolation are risk factors for psychological vulnerability post-loss (Burton et al. 2007; Utz et al. 2012).

The quality of medical care one's late spouse received at the end of life and their place of death also affect the widow(er)'s psychological adaptation. Those who believe that their spouse was in pain or received problematic medical care at the end of life report greater anxiety and anger post-loss than persons whose loved one had a "good death" (Carr 2003). Conversely, the use of hospice or palliative care services is associated with greater psychological resilience and fewer depressive symptoms (Ornstein et al. 2015). These studies reveal the importance of moving beyond examinations of resilience following a single or isolated stressor. Studies that fail to consider the multiple pathways into and secondary stressors following spousal loss may draw misleading conclusions about psychological resilience post-loss, and may attribute individual-level differences to traits, such as optimism, positive affect, or locus of control (Rossi et al. 2007). While understanding the psychological traits linked with resilience is an important goal, researchers also should identify aspects of the stress context that enable or inhibit resilience, as the first step toward developing interventions to improve the context of death, dying, and end-of-life care.

Conclusion and Future Directions

In this chapter, I have shown that resilience is a common emotional reaction to spousal loss in later life, with most older widows and widowers showing no, modest, or short-lived symptoms of distress (Bonanno 2004; Bonanno et al. 2002). Drawing on conceptual models of stress and coping, I argued that the extent to which one is resilient or vulnerable in the face of a major stressful event, most notably spousal bereavement, is a function of the larger social context, including the role history, the availability of social support, and the nature of the loss, including its timing and expectedness. While research on resilience historically has focused on personal traits that enhance one's capacity to positively reinterpret, withstand, or bounce back from stress—like optimism, self-determination, and grit (see Resnick, this volume, for review), it is equally important to consider the situational factors that make some stressors easier to "bounce back" from than others. From a policy and practice standpoint, interventions such as providing caregiving supports for

older spouses, household assistance to older bereaved spouses, and high-quality end of life care to their dying partners may be just as effective in helping older adults adapt bereavement as are interventions targeting personal traits like optimism and control.

The research synthesized in this chapter also underscores that few stressors occur independently or in isolation of one another, and the impact of any particular stressor on psychological resilience is conditioned by the stressors that occur prior, alongside, or following it. For instance, financial strains and difficulties with household chores following spousal loss heighten one's psychological vulnerability, while financial stability and an enhanced sense of confidence in managing chores bolsters resilience (Carr 2004a; Lee et al. 2001). Yet researchers have only begun to scratch the surface in exploring psychological resilience in the face of multiple overlapping or accumulating stressors. This is a critical avenue for future research, as studies that focus exclusively on single discrete stressors do not adequately capture the actual lived experiences of stress.

Researchers know relatively little about psychological resilience among persons (and bereaved persons, in particular) growing old under conditions of extreme adversity. Most bereavement research relies on large sample survey data sets or help-seeking samples; both of these populations are over-representative of those who are socially engaged, capable cognitively and emotionally of participating in a survey, or who are seeking help—characteristics which are linked with psychological resilience (Richardson 2002). Consequently, those growing old under highly adverse circumstances, including homebound, homeless, imprisoned, detained, displaced, or impoverished older adults often are systematically excluded from such studies. Over the past five years, social scientists have paid increasing attention to the vast social and economic disparities evident among older adults (e.g., Abramson 2015; Carr 2019), as well as those displaced due to natural disasters (Merdjanoff et al. 2019) or political upheavals (Madi et al. 2019). A core theme of stress process models is that the accumulation of chronic and acute stress is most harmful, yet few studies explore how bereavement affects the psychological resilience of older adults living with concurrent strains, such as food and housing insecurity, imprisonment, or the loss of long-standing social supports due to political or disaster-related displacement (Schafer et al. 2009). Understanding the sources of resilience (and vulnerability) among highly disadvantaged older adults typically absent from population-based research will be critical for challenging, refining, and advancing our knowledge about the limits and potentials of psychological resilience.

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Physical Resilience and Aging

Sue Peters

Abstract Physical resilience is defined as the ability to optimize/recover function in response to the stressors (adversities) of disease, injury, or age-related physical decline, and is multifaceted with areas of overlap between biological, sociological, and psychological factors. This chapter focuses on physical resilience as it relates to rehabilitation of older adults with pathologies that limit motor function. After defining physical resilience, rehabilitation, and recovery, physical resilience research is summarized as it relates to the biology, psychology, and sociology of motor function and aging. The last section deals with research that more explicitly examines the interactions or areas of overlap, and can be considered an examination of the biopsychosocial aspects of physical resilience research as it relates to motor function and aging. Finally, physical activity is discussed as a potential way to assess and improve physical resilience. Future directions are discussed among which are suggestions as to how physical resilience research may be incorporated into clinical practice.

Overview

Resilience is currently studied in many areas such as social, psychological, biological, and medical research (Whitson et al. 2016; Hadley et al. 2017). While a variety of different conceptualizations and types of resilience have arisen, most of these have focused on psychological or social-psychological realms (Masten 2007; Cosco et al. 2018). One area in which resilience conceptualizations and discovery show promise is physical resilience, especially applied to older adults, who experience more rapid age-related decline in motor function. *Physical resilience* is defined as the ability to optimize/recover function in response to the stressors (adversities) of disease, injury, or age-related physical decline, is multifaceted with areas of overlap between biological, sociological, and psychological factors (Resnick et al. 2011;

S. Peters (*)
Rehabilitation Research Program, GF Strong Rehabilitation Centre, Vancouver, BC, Canada

Department of Physical Therapy, Faculty of Medicine, University of British Columbia, Vancouver, BC, Canada
e-mail: sue.peters@ubc.ca

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Whitson et al. 2016; Hadley et al. 2017; Colon-Emeric et al. 2019; Peters et al. 2019). While resilience literature may use the term "adversity," some *physical resilience literature* uses the term "stressor" to indicate bodily disease, injury, functional decline, in contrast to the mental health literature's use of the term "stressor," and thus, this chapter will generally use "stressor" instead of "adversity" (Resnick et al. 2011; Whitson et al. 2016; Hadley et al. 2017; Colon-Emeric et al. 2019; Peters et al. 2019). This chapter focuses on physical resilience as it relates to rehabilitation of older adults with pathologies that limit motor function. Generally, this chapter deals with the research around the following questions: (1) What differentiates those who improve or bounce back from those who do not? and (2) Can mobility rehabilitation be improved with knowledge of physical resilience?

Though some conceptualize resilience as a binary state, on a continuum, resilience is regarded as a contrast to vulnerability (Franco et al. 2009). High levels of resilience can confer desirable health outcomes, such as reduced length of rehabilitation together with better motor function (Hadley et al. 2017). Resilience is also recognized as part of adjusting to aging processes (Wagnild and Young 1990). The aging process itself is often accompanied by the onset of acute and chronic illnesses or diseases (Salive 2013), and for many older adults, these conditions broadly affect many aspects of life, such as activities of daily living, social roles, and mental health (Wister et al. 2016). Furthermore, clinical data from the United States of America (USA) show that many older adults have ≥2 of 15 common chronic illnesses, with multimorbidity prevalence rates of 62% of persons aged 65–74, 75.7% aged 75–84, and 81.5% aged 85+ (Salive 2013). Comparable patterns are observed in Canada and Australia, with variability contingent on the type of data, population, and the quantity of chronic illnesses (Wister et al. 2016). Aging is often accompanied by increases in psychosocial (ex. bereavement, loss of home) and physical stressors (ex. hip fracture, stroke, surgery), and may also be associated with decline in ability to respond efficiently to these types of stressors (Hadley et al. 2017). Considering that many older adults live with multiple chronic conditions, and/or losses in functional ability (Salive 2013; Wister et al. 2016), greater understanding of the role of physical resilience in the context of aging is needed (Wister et al. 2018). Greater knowledge of resilience in a health trajectory framework may also help to conceptualize mobility outcomes. Before discussing the research around physical resilience, a few definitions are required.

Important Definitions

Physical Resilience is the ability to resist functional decline, or optimize/recover function in response to *physical stressors* such as disease, injury, or age-related physical decline (Resnick et al. 2011; Whitson et al. 2016; Hadley et al. 2017; Colon-Emeric et al. 2019; Peters et al. 2019). At the whole-person level, physical resilience is not limited to a single organ system, but involves multiple organ systems. The particular aspect of physical resilience covered in this chapter is

examination of physical resilience as it relates to motor function, such as regaining gait speed after a loss of muscle strength. *Physical stressors* can be acute or chronic in nature, or multiple acute stressors spaced out in time or occur concurrently. There is also a fourth scenario: physical stressors can be "acute on chronic," such that a chronic condition may have an acute exacerbation of that condition with a subsequent removal or reduction of the acute exacerbation. For example, in relapsing-remitting multiple sclerosis (one of four types of multiple sclerosis), acute relapses of the condition occur following periods of complete or partial recovery to baseline function. Over time, delays in returning to baseline function may contribute to the reduction to basal levels of physiological systems with slow deterioration to motor functions like gait speed.

Rehabilitation "reflects a process of care" (Bernhardt et al. 2017). The definition of rehabilitation as developed by the British Society of Rehabilitation Medicine (also used by Bernhardt et al. 2017) is as "a process of active change by which a person who has become disabled acquires the knowledge and skills needed for optimum physical, psychological and social function." One condition that requires high levels of physical resilience for motor function recovery is stroke. Stroke rehabilitation, as defined by World Health Organization, "encompasses coordinated delivery of interventions provided by two or more disciplines in conjunction with medical professionals, as team aims are to improve patient symptoms and maximize functional independence and participation (social integration) using a holistic biopsychosocial model, as defined by the International Classification of Functioning Disability (ICF)" (Organization, 2001; Bernhardt et al. 2017). Thus, rehabilitation by medical professionals is a key element within the health care system, wherein components of physical resilience could be identified and fostered.

Recovery is the return of body structure, function, and activities to pre-disability/pathology state, which can be measured by change of an outcome between 2 or more timepoints, and can also be measured by "mechanisms underlying this improvement in terms of behavioral restitution or compensation strategies" (Bernhardt et al. 2017). For a change of outcome to be defined as recovery, there must be an improvement in the outcome measured. Thus, measures of recovery may shed light on physical resilience.

Defining Recovery within a Physical Resilience Framework

Two conceptual approaches can be used to define recovery: (1) the recovery phenotype and (2) the expected recovery differential (Colon-Emeric et al. 2019).

Recovery phenotype uses statistics to generate a composite score which can incorporate multiple outcomes at the same time, or uses recovery trajectories to identify patients with similar recovery profiles (see example below). Thus, this is something to keep in mind when reading physical resilience research: patients who exhibit the greatest levels of physical resilience in research using *recovery phenotype* are likely to be composed of younger and potentially healthier individuals.

Expected Recovery Differential quantifies a predicted outcome with population-based models, and a patient's clinical demographics and clinical measures, then compares these metrics to the actual outcome of the patient (see example below). Importantly, different approaches for examining physical resilience will yield different classification for the same patient (Colon-Emeric et al. 2019). The "expected recovery differential" approach identifies patients who recover faster or better than expected in that the metrics used to define recovery outcomes are more highly scored than underlying circumstances may have predicted. These expectations can be based on demographics, environmental support, comorbidities, etc. For example, a frail woman in her 70s with limited ambulation who has a severe stroke may not be expected to regain mobility to pre-stroke levels (predicted outcome). If she exceeds those expectations (actual outcome), she has a large expected recovery differential (difference between predicted and actual outcome) and displays high levels of physical resilience. Importantly, insight into the mechanisms of physical resilience may be uncovered as highly resilient individuals can be identified and further examined for underlying physiological protective mechanisms. Further clinical examples (viral respiratory patients, and hip fracture patients) are outlined in Colon-Emeric et al. (2019).

Recovery Phenotype Vs. Expected Recovery Differential

The recovery phenotype encapsulates observed outcomes through multiple measures. In a study using the expected recovery differential in a group of patients with viral respiratory infection, a sicker group with more comorbidities was identified as being highly resilient compared with a recovery phenotype method, as well as a healthier group classified with lower physical resilience (Colon-Emeric et al. 2019). For instance, a frail 75-year-old woman with severe cognitive impairment and limited social support, who walks independently prior to a stroke, may not be expected to attain independent gait post-stroke. If she does gain the ability to walk even with assistance, she could be classified as physically resilient using the expected recovery differential approach, but not resilient using the recovery phenotype approach. Thus, patients who exhibit high physical resilience using *recovery phenotype* are likely to be younger, healthier individuals. Using the *expected recovery differential* approach may include older and robust people who may have comorbidities who recover well despite these additional challenges.

Stressors

In addition to psychological and social factors, an important aspect of physical resilience is a physical stressor. Stressors may have additive or synergistic effects when multiple stressors are experienced (Table 1). There can be different intensities of

Table 1 Common physical stressors in older adults

Elevated/lowered serum glucose
High blood pressure/cholesterol
Arteriosclerosis
Osteoarthritis/inflammatory arthritis
Reduced vision/hearing
Altered balance/vestibular system function
Bed rest (result of infection, flu, etc.)
Trauma from falls (fracture, musculoskeletal)
Reduced peripheral sensation
Sarcopenia
Osteoporosis/osteopenia
Cognitive decline
Multimorbidity

stressors that range from mild to severe. Thus, a strong body system experiencing a mild stressor may easily mount a physically resilient response (see example below). Conversely, a mild stressor to an already taxed system may leave few resources, and tip a system toward failure. In another situation, a maximal stressor (i.e., a stressor that does not kill an individual) to a strong system may only leave mild impairment, yet the same stressor to a taxed system may leave an individual with high impairment. A single stressor may impact multiple body system, and yet multiple stressors may impact the same body systems or different body systems, and impact physical resilience. A particularly strong body system may help to compensate for one or more body systems that are undergoing high levels of stressors. For example, in the brain, one of the main motor output pathways, the corticospinal tract, is often damaged in a stroke that impacts motor function (Schulz et al. 2017). An individual after stroke may recover motor function through multiple means one aspect being that the corticospinal tract has 10% of fibers that do not cross the midline in the spinal cord (Armand and Kuypers 1980). Thus, the corticospinal tract of the non-lesioned hemisphere can contribute to function of the paretic or weaker limb. Also, other regions of the brain, like the supplementary motor and premotor areas, have some corticospinal tract neurons which can help to compensate with increase in activation (Kato et al. 2002; Ruber et al. 2012), and ultimately, contribute to the recovery of motor function.

The following sections summarize some physical resilience research related to the biology, psychology, and sociology of motor function and aging. The last section deals with research that more explicitly examines the interactions or areas of overlap, and can be considered an examination of the biopsychosocial aspects of physical resilience research as it relates to motor function and aging.

Biology

Physical resilience cuts across multiple organ systems (i.e., is at the whole-person level) and is the integration of molecular, cellular, and system-level processes (Colon-Emeric et al. 2019). Multiple contributors to motor function may serve as redundancies, which is good news for maintaining quality of life with aging (Fig. 1). There are known biological changes that occur with aging; molecular changes like mitochondrial dysfunction, and cellular senescence are a few examples (Hadley et al. 2017). Over time, molecular changes can lead to changes in physical resilience with aging. In an older adult, perfect health may be the ideal state in which an individual has many redundancies in their biological systems, with low energy consumption (i.e., few or no pathology). A biologically stressful event is likely to occur at some point with aging and depending on the insult and the biological state, the individual may experience a progressive decline in health, or they may mount a physical resilience response that allows for a state of stability that may be lower than "perfect health," less energy efficient with less biological redundancies, yet still homeostatically stable. This stability can remain until another stressor(s) is applied. The individual could progressively adapt with each subsequent stressor ending up in optimal homeostasis considering the biological systems available to them, until there are no more redundancies left. A greater number and level of stressors in an individual who starts with perfect health would allow them to reach an older age before succumbing to health stressors.

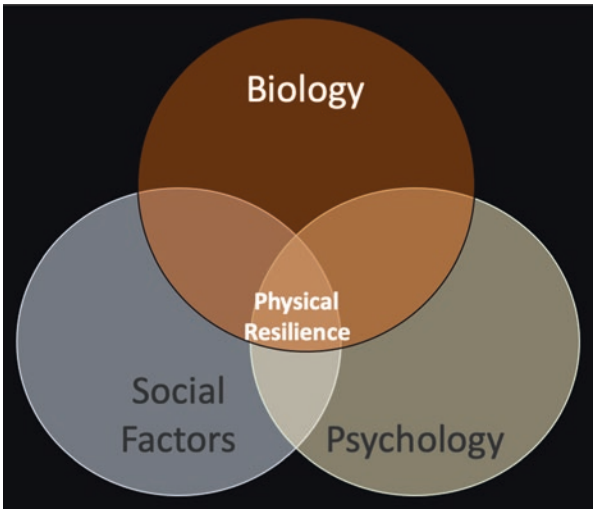

Fig. 1 Highlighting the overlap of biology with social factors and psychology in physical resilience

Reserve

The concept of "reserve" has been used to explain the difference between individuals in their capacity to cope with or compensate for pathology. In the literature, there are many forms that reserve can take, such as brain or cognitive reserve, and muscle or bone reserve (Piccinini et al. 2018). It can be thought of as the difference between baseline function and the maximum capacity of the body system or individual to respond. As a general rule, *some* stress *increases* reserve, however, *too much stress depletes* reserve (for further reading, the concept of "steeling" or the potential strengthening effect of stressors is expanded on in Rutter 2012). If we consider bone density, a bone's amount of reserve is the difference between the maximum capacity to withstand stress, and the actual amount of stress applied. If a stressor exceeds the maximum capacity, a fracture may occur. In bone, a prior stressor can increase the amount of reserve (i.e., resistance exercise can increase bone density), and thus improve resilience to a higher level of potential future load withstanding larger amounts of physical stress. Thus, physical resilience is increased. There may be a threshold that, if the degree of stress applied is above this level, the body system is unable to return to normal levels, resulting in an increase in the potential for *vulnerability response* (e.g., bone fracture) as opposed to a *resilient response* (e.g., no fracture). Ultimately, the same level of stress makes one person be admitted to a long-term care facility and another person remains living at home. Overall, at the time a stressor is applied to the system, the degree of reserve influences the response trajectory.

We can also consider gait speed as an example (Middleton et al. 2015) established gait speed cut-off values of 0.8 m/s as a threshold within which slower speeds tend to indicate limited community ambulation as well as increased risk of hospitalization and falls. Faster gait speeds are associated with safe community ambulation (i.e., fewer or no falls), fewer hospitalizations, and independence in activities of daily living. While two individuals may be able to comfortably walk at the same speed, they may have different levels of gait speed reserve, or fastest gait speed. If the same stressor is applied to these two individuals, altered trajectories of recovery would produce different outcomes that may be above or below 0.8 m/s. If prior to the stressor, an individual has a large reserve, less recovery could take place, but the individual could still be able to walk at a gait speed safe for community ambulation. While response trajectory can depend on reserve, it also relates to the dose or magnitude of the stressor. Knowledge of the stressor itself (i.e., pathology) could be important for increasing understanding of the thresholds needed for an optimal physical resilience response. Yet, physical resilience is more than biology. Multiple factors in combination influence physical resilience with aging: health behaviors, income, education, sex, marital status, ethnicity, culture, purpose in life, self-concept, efficacy, mood, social networks, etc., come together to influence motor function and reflect the functional limitations associated with disease and disability

(Seals et al. 2016). Social factors and psychological traits (including emotional) may modulate the basic biological mechanisms of aging as these factors exert effects on the central nervous system, alter peripheral signaling, gene transcription, and cellular function (Seals et al. 2016).

Psychology

There are psychological aspects that contribute to physical resilience. Psychological characteristics of resilient individuals include those high in commitment, challenge, and perceived control (i.e., internal locus of control) (Crust and Clough 2005; Maddi 2005) (Fig. 2). If we consider the example of an individual going through stroke rehabilitation, a high level of commitment may provide a strong sense of purpose so they can get better to care for grandchildren or go back to work. For challenge, the individual with stroke may push to be as involved as possible with rehabilitation processes, in which the mobility limitation post-stroke is viewed as a challenge to overcome or an opportunity for development. For control, the individual with stroke to exhibit a high internal locus of control would need to feel not helpless or at the mercy of the unilateral weakness. Thus, psychological characteristics are important factors when considering an individual's physical resilience during the rehabilitation process.

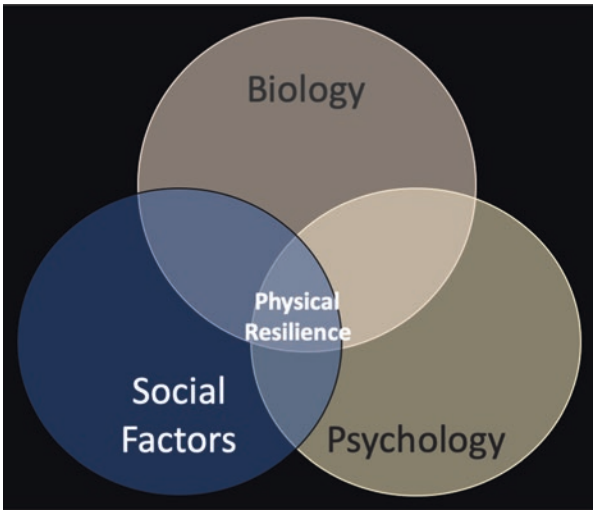

Fig. 2 Highlighting the overlap of social factors with biology and psychology in physical resilience

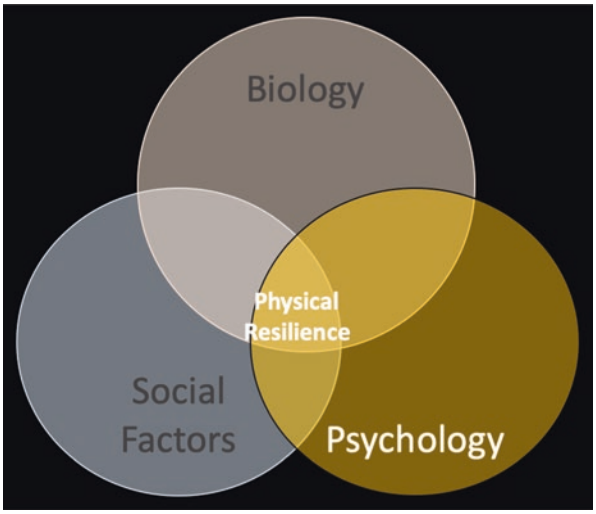

Fig. 3 Highlighting the overlap of psychology with biology and social factors in physical resilience

Social Factors

Social support factors are also important predictors of variability in physical function (Koukouli et al. 2002). Active coping is acting or exerting efforts to remove or circumvent a stressor (Fig. 3). In other words, active coping are the ways that an older adult and their family engage and respond to medical issues, and impacts the ability to adapt and thrive. For example, older adults awaiting a liver transplant, a positive relationship between physical function and resilience is partly explained by higher levels of active coping and perceived social support (Swanson et al. 2018). While social factors seem essential to physical resilience, sparce research examines this element within a rehabilitative context.

Bio-psycho-social Factors

Rehabilitation currently lacks a framework that incorporates social factors and psychology with biology. A comprehensive physical resilience framework which incorporates social, psychological, and biological factors may advance understanding of the association among physical resilience and health outcomes (Johnson et al. 2019) (Fig. 4). A theoretical model for physical resilience suggests that it is comprised of features of the physical stressor itself, psychological characteristics, social support, and environmental aspects as necessary elements to achieve recovery after a stressor that affects health (Fig. 1 in (Colon-Emeric et al. 2019)).

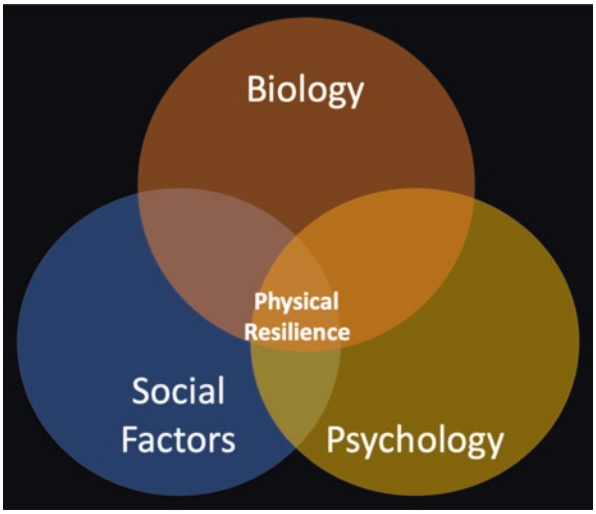

Fig. 4 Overlap of biology, social factors, and psychology in physical resilience

Physical health is more than biology. In one quasi-experimental study, residents living in a nursing home were divided into two groups and exposed to different interventions (Mallers et al. 2014). The first group could arrange their furniture, go where they wanted, spend time with whom they wanted, etc. In other words, they were given control and responsibility. The second group were told that staff there to take care of and help them. At the end of the study, the first group demonstrated overall improved health, whereas in the second group, a greater proportion had died. Situations like this occur in rehabilitation, for example, family members try to support a patient by doing everything for them, and ultimately, recovery can be lessened with too much care. Thus, maintaining as much personal control as possible with aging may increase or maintain levels of physical resilience with aging. At the genetic level, certain genes' expression can be based on levels of social isolation (Cole et al. 2007; Cole 2013). These studies analyzed the influence of social factors on gene expression profiles in blood from otherwise healthy older adults who differed in the extent that they felt socially connected to others. There were different levels of expression in people who consistently felt lonely and distant from others over the course of 4 years (Cole et al. 2007). Consequently, there is a link between social factors and biology. Social isolation is associated with diseases such as heart disease, neurodegenerative diseases, and some types of cancer, as well as reduced responses to vaccines and viral infections.

In individuals aging with physical disabilities, higher levels of resilience are associated with better physical function, less depressive symptoms, and higher social function (Silverman et al. 2015). Over 3 years, higher levels of baseline resilience predicted reduction in depressive symptoms and increased social functioning, which supports the observation that resilience may be a protective factor supporting optimum physical function in individuals who are aging with disability (Silverman

et al. 2015). For individuals with multiple sclerosis, significant longitudinal relationships exist for social support, resilience, and mental health outcomes (Koelmel et al. 2017), so that future research concentrating on resilience-focused psychological interventions may potentially show an effect on motor outcomes. To survive cancer and the associated declines in function, individuals tend to be younger with higher baseline physical function and general health, with higher education and income levels, and more likely to be of Caucasian decent (Duan-Porter et al. 2016). Older adults who demonstrate physical resilience report higher self-efficacy and social support, shown in a majority of older adults who had survived cancer; thus, examining and directing interventions to include psychosocial factors may be important to foster physical resilience (Duan-Porter et al. 2016).

Cole (2013) proposed a possible mechanistic process for how social factors and psychology influence biology (Cole 2013). First, the social environment can activate the central nervous system processes that influence hormonal and neurotransmitter activity in the brain and throughout the body peripherally. Within the body, these signaling molecules can activate transcription factors that can promote or repress gene expression. The expression of these genes impacts health and behavioral phenotypes after the genes are transcribed. Individual differences in genes and gene expression can affect the subsequent sensitivity or reaction to the social environment.

Aspects of a Physically Resilient Phenotype

Prior to understanding mechanisms that drive these processes, and prior to designing interventions to enhance physical resilience, a physical resilience phenotype requires defining. One reason developing and understanding resilient phenotypes is important is that this knowledge can assist with developing clinical prediction rules and tools to better target patients with health services and clinical programs that better meet their needs with more efficient resource utilization. The necessary physical resilience phenotype may depend on the type of physical stressor (i.e., physical resilience associated with hip fracture may require the combination of different factors than the physical resilience associated with a stroke). Before moving on to discuss physically resilient phenotypes, it must be stated that there is currently no gold standard to define physical resilience phenotypes or quantify physical resilience. Clinically, the physically resilient phenotype may look like an individual with resulting clinical outcome measure scores that improve to a higher level or more quickly than expected (Hadley et al. 2017). Post hip fracture, a potential consequence is persistent mobility limitation or fracture non-union. A resilient phenotype may demonstrate gait recovery in less than 1 month (i.e., quicker than expected) with a unionized fracture. The physiological systems that require resilient responses include the musculoskeletal, circulatory, and neurological systems. In another example, infection exposure could potentially result in mortality, restricted mobility, or septicemia. An individual with a resilient phenotype to this stressor could

avoid the infection despite exposure, or recover more quickly from infection than expected. The physiological systems with resiliency would include the immune, pulmonary, and genitourinary systems. Physical stressors typically affect one or more organ systems to a larger extent than others, which could allow for measurable and distinct physical resiliencies (Colon-Emeric et al. 2019). Individuals that demonstrate the highest levels of recovery across multiple domains could be defined as having the maximum physical resilience. Thus, depending on the nature of the physiologic stressor, different body systems may be required with different levels of resiliency or combinations of resiliency.

In Franco et al. (2009), the "healthy aging phenotype" is signified by ideal levels of reserve and biological resilience (Franco et al. 2009). The definition includes "highly preserved metabolic, hormonal, neuro-endocrine control systems at the organ, tissue, and molecular levels" (Franco et al. 2009). Again, multiple body systems work together in synergy to generate resiliency against physical stressors. These individuals tend to have higher levels of physiological complexity with larger heart rate variability, more complex neural structure and function, greater bone density, etc. Greater physiological complexity could mean these individuals possess a larger range of potential adaptations to greater variance in physical stressors. Important aspects of the healthy aging phenotype may be age- and gender-specific as these factors also interact with environmental, social factors, and genetics/epigenetics. Conceiving physical resilience as a phenotype could potentially be used to describe more complex patterns of recovery of motor function, as it integrates multiple outcomes in this way.

The *recovery phenotype approach* is grounded in clinical thinking as it starts with actual observed clinical events, then uses statistics to classify recovery pattern, a method appropriate for prognostic models in clinical practice to identify high and low risk groups (Colon-Emeric et al. 2019). A clinical classification system can be developed that defines recovery phenotype according to multiple clinical outcomes. For example, can order older adults by mortality, ICU admission, length of stay, self-reported motor function, etc., then divide individuals into equal groups using logical cut points. The group with the lowest physical resilience may include those patients who died or had a lengthy ICU stay, compared with a group with the highest physical resilience who may have shorter hospital stay with no mortality (Colon-Emeric et al. 2019). A potential limitation of this approach is that social factors and psychological factors are not often measured during acute hospital stays, so these factors may not be involved in current research examining factors involved in recovery phenotyping.

Another *approach is using principal components analysis (PCA)* with inclusion of correlated variables such as length of stay, ICU admission, mortality, etc., with the PCA searching for joint variation in a linear combination of measured observations. The benefit of this approach is a weighted outcome score for each patient as a measure of recovery phenotype and is a continuous variable (vs. the clinical classification system which puts an individual into a group). As a continuous variable, the results of the PCA can provide a higher amount of statistical power when examining associations between variables: statistical power is the probability of correctly

rejecting a false null hypothesis. Said another way, it is the chance of getting a significant statistical test result when there is an actual difference in the population. Further, if a clinical classification is desired as an outcome, the PCA scores can be further divided into groups (i.e., quartiles). If the reader is interested, additional description of further methods can be found in (Colon-Emeric et al. 2019).

While both PCA and classification systems can be used to define expected recovery differential (Colon-Emeric et al. 2019), potential limitations to research of recovery phenotypes are that it requires large sample sizes and is sensitive to missing data. If a particular study is expecting a smaller sample size, the expected recovery differential approach may better uncover underlying mechanisms, or biomarkers of physical resilience, as this approach may require less adjustment for degrees of freedom. Another limitation that will be difficult to overcome is that phenotyping approaches are complex: The more we understand physical resilience and phenotypes, the more complex classification systems are becoming. Increases in complexity lend itself to difficulty with clinical application, which is the ultimate goal of this work.

Something that is not often discussed in the literature is that physical resilience likely requires some luck. As different physical stressors require different combinations of strength from various body systems, if an individual is lucky enough to be exposed to a stressor in which that particular individual has strong/high resiliency in those body systems, they could recover and adapt quickly and easily. If the same individual is unlucky to be exposed to a stressor in a body system that they are weak in, the individual could be vulnerable to the worst effects of that pathology.

Measurement of Physical Resilience

Physical resilience can be measured as dichotomous trait (occurrence or nonoccurrence) or as continuous variable. Many current measurement instruments have ceiling effects and are limited in ability to characterize high levels of motor function. For example, the Berg Balance Scale, often used in rehabilitation hospitals to quantify balance recovery after stroke, has a ceiling effect for community-dwelling individuals so if this scale was used to identify individuals who are physically resilient with balance, many individuals will be identified who may still have balance deficits that prevent them from full community mobility (Blum and Korner-Bitensky 2008). Thus, other scales are being recommended to assess balance (Chen and Smith 2018). Better methods or measurement instruments to predict and assess physical resilience (and identify vulnerable individuals) in older adults may allow early treatment and prevent or reduce motor function limitations (Hadley et al. 2017). Enhanced measurement would improve: (1) therapeutic decision making, (2) prehabilitation including decreasing risk of adverse events like falls/infections, (3) rehabilitation to increase how well and how quickly an older adult may recover, and (4) acute care management to identify complications quicker.

As healthy biology is required for healthy aging, and involves multiple tissues and organ systems, physical resilience measurement instruments should contain multiple clinical outcomes for each individual (Colon-Emeric et al. 2019). Then, a clinician or researcher could use statistical approaches to generate meaningful incorporation of multiple outcomes. Multiple measurement instruments could each capture an element of physical resilience, or future research could work toward generating 1 measurement instrument to capture all aspects of physical resilience in an outcome measure that can be quickly and easily administered by hospital or clinical staff. To be useful in rehabilitation, a measurement instrument should sufficiently capture the shifting or changing of physical resilience, to better serve the individual (i.e., identify problems before they become irreversible). There may be several possible alternative strategies to maintain physical function (i.e., use of compensatory muscle activation patterns to be able to walk), though these alternative strategies may come with the introduction of new or exacerbation of existing pathologies (i.e., compensatory muscle activation patterns that over time, lead to muscle shortening, pain, and further decline in ability to walk). A benefit of identification of a physical resilience measurement instrument is that it could quickly assess the benefits and risks of novel interventions.

Physical Activity – A Path to Physical Resilience?

Physical inactivity is the fourth leading cause of death worldwide (Kohl et al. 2012). Assessing exercise capacity through the physiological responses to vigorous exercise (like fast gait) can determine levels of resistance to stress and thus could be a marker of physical resilience (Miller et al. 2017). Looking at maximum exercise capacity in this way, and the physiological responses associated with it, is a strong predictor of morbidity, frailty, and mortality risk in middle to older age adults, and potentially, could be a biomarker of physiological stress resistance (Miller et al. 2017). For example, individuals with high aerobic fitness are associated with fewer chronic diseases (Silverman and Deuster 2014). Regular physical activity affects multiple systems and pathways like decreased risk factors for cardiovascular disease, decreased risk of developing diabetes, and decreased risk of mortality (Franco et al. 2009). Improving physical fitness through physical activity can confer physical resilience by inducing improved physiological responses and decreased reactivity to physical stressors, and thus, protect from deviations in health preventing chronic diseases (Silverman and Deuster 2014). Better physical fitness can minimize inflammation that can be associated with chronic psychological stress, physical inactivity, and abdominal adiposity.

Regular physical activity induces positive physiological, psychological, and social benefits (Deuster and Silverman 2013). Specifically, cardiovascular fitness is a predictor of mortality in older adults, with increases in cardiovascular fitness improving brain function, musculoskeletal system, and metabolic status (Franco et al. 2009). However, more research is needed to better understand health outcomes

related to frequency/intensity/duration of physical activity to determine the optimal dose for older adults to improve cardiovascular status and overall physical fitness.

Beyond physical activity alone, a combination of strategies is suggested to increase physical resilience. Recent approaches for supporting successful aging involve physical (like vigorous exercise), cognitive, and social activities, in addition to having a healthy lifestyle, with social support, and positive psychological traits such as optimism (Kamat et al. 2017). These approaches are commonly recommended to older adults without severe disorders, nevertheless, emerging evidence suggests these approaches are important to foster physical resilience in older adults with neurologic and other diseases as well (Kamat et al. 2017). Some potential ways to increase physical resilience with aging include working toward maximizing current motor function (i.e., increase physical activity). If an older adult already has movement difficulty, physiotherapists as well as some kinesiologists and exercise physiologists may be able to assist. Physiotherapists are especially well-suited to assess motor impairments and design an exercise program to maintain and potentially improve functional mobility. Kinesiologists and exercise physiologists can provide guidance for physical activity as well.

Future Directions

Future work will be required to incorporate physical resilience into rehabilitation. More specifically, research on the determinants of resilience, both at the physiological and psychosocial levels, in response to physical stressors and interventions that modulate or support resilience levels can improve health outcomes (Hadley et al. 2017). Furthermore, there is a need to research which multi-factorial approaches in which combination can foster physical resilience. A key aspect for a high resilience response is to engage one's own physical resilience resources when pathology strikes. If an older adult can maintain an element of personal control, there may be an increase in likelihood of generating a resilience response. There may be a need for measurement instruments or biomarkers that capture aspects of physical resilience with efficacy and ease for use in clinical practice. To this end, there may be a need for pathology-specific measurement instruments.

Based on Colon-Emeric et al. (2019), future work may consider that patients who exhibit the greatest levels of physical resilience in research using the *recovery phenotype* are likely to be composed of younger and potentially healthier individuals (Colon-Emeric et al. 2019). Using the *expected recovery differential* approach, older and more robust adults who may have comorbidities, who recover well despite these additional challenges, may be identified. Thus, the expected recovery differential approach may prove useful, as it may identify underlying characteristics across functional domains, and ultimately, may be more useful to isolate fundamental biological mechanisms that support resilience in older adults (Colon-Emeric et al. 2019). Future strategies should include those approaches that show promise not only at the individual level, but also at the population level. These strategies

must also focus on how to integrate technology and cluster interventions to augment physical resilience and structure communities that allow for aging-in-place (Kamat et al. 2017).

Integration of Physical Resilience into Clinical Practice

Attempts to integrate physical resilience into clinical practice should commence with a complete assessment, which includes examination of physiological factors as well as social and psychological factors. If physical resilience can be proven to be a "whole-person level characteristic that cuts across organ systems…. then interventions that enhance physical resilience have the potential to improve multiple outcomes in response to a variety of different stressors" (Hadley et al. 2017; Colon-Emeric et al. 2019).

Physical resilience is *complex*. There are intersections between biology, psychology, and social factors. The good news is that it appears that older adults can tap into redundancies or elements of strength to navigate stressors, to maintain motor function with aging.

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Mobility Resilience Processes Among Older Adults

Kishore Seetharaman, Andrew V. Wister, and Theodore D. Cosco

Abstract This chapter integrates resilience frameworks (Richardson, J Clin Psychol 58:307–321, 2002; Wister et al., Int J Aging Hum Dev 82:290–313, 2016) with processes of adaptation articulated in the Selective Optimization and Compensation (SOC) model (Baltes and Baltes, Successful aging: perspectives from the behavioral sciences. Cambridge University Press, New York, 1990) to understand mobility challenges among older adults, termed mobility resilience. Forty-one studies were reviewed to identify the range of adaptive processes employed by older adults with mobility limitations in order to explore how these strategies are associated with the different classes of reintegration in the resilience model. The linking of models of resilience and adaption helps to (i) explain why some older adults adapt to or recover from mobility limitations better than others and (ii) understand the factors and processes involved in building mobility resilience, which in turn can guide the development of programs that enhance older adults' health and well-being.

Introduction

The Resilience Framework

The concept of resilience has been receiving increasing attention in gerontology research over the past two decades. This is suggested to be an improvement over successful aging models since the resilience framework is more inclusive of older adults experiencing adversity and exhibiting positive adaptation than models focusing only on individuals with little or no adversity (Cosco et al. 2017). Moreover, successful aging models fail to adequately explain the contrast between the lived

K. Seetharaman (✉) · A. V. Wister
Department of Gerontology, Simon Fraser University, Vancouver, BC, Canada
e-mail: kseethar@sfu.ca; andrew_wister@sfu.ca

T. D. Cosco
Department of Gerontology Research Centrre, Simon Fraser University, Vancouver, BC, Canada
e-mail: theodore_cosco@sfu.ca

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experience of individuals and negative outcomes, whereas this is a focal point of the model of resilience (Wister et al. 2016). Specifically, it has been contended that the resilience framework contributes to a more complete understanding of adaptive aging processes since (i) older adults are known to dedicate more resources towards resilience rather than optimal development and (ii) resilience resources are more advanced and well developed in later life (Wild et al. 2013). Applied to health-related adversity, another advantage of applying a resilience perspective is that it is based on a salutogenic and non-deterministic approach that highlights the positive aspects of well-being associated with coping and adaptive processes that can both protect older adults from the negative effects as well as foster recovery (Wild et al. 2013; Wister et al. 2016).

According to the American Psychological Association (APA) (2019), resilience is "the process of adapting well in the face of adversity, trauma, tragedy, threats, or significant sources of stress" and is commonly viewed as individuals "bouncing back" from challenging health and life events. Previous studies have conceptualized resilience as both a personality trait that is inherent in individuals and a process involving transactional relations with the environment (Jacelon 1997; Wiles et al. 2012). Indeed, most of the early work stemmed from developmental psychology, with a focus on individual elements of resilience (Ong et al. 2009; Wister et al. 2016). However, more recent scholarship views resilience as a *process* of context-specific person-environment (P-E) interactions involving (i) *risk factors* (i.e., social, environmental, cultural, or demographic factors that expose individuals to a greater extent to stress and amplify associated negative outcomes) and (ii) *protective factors* (i.e., factors that mitigate the impact of risk factors and result in positive outcomes) occurring at different hierarchical levels of the environment (e.g., at the level of the individual, household, family, neighbourhood, community, and society) (American Psychological Association 2019; Lavretsky 2014; Stainton et al. 2019; Staudinger et al. 1993; Tusaie & Dyer 2004; Wild et al. 2013; Wiles et al. 2012; Wister et al. 2019). Furthermore, resilience has been conceptualized as an *ongoing* process of negotiating losses, adapting to circumstances positively, and reintegrating self (Richardson 2002; Wister et al. 2016). The expression of resilience is guided by at least the following key dimensions: (i) the experience of adversity; (ii) meeting adversity with a positive/adaptive response, which is significantly more effective than the normal response in a stressful situation; and (iii) the experience of greater positive outcomes than expected under risky circumstances (Cosco et al. 2017; Ong et al. 2009; Stainton et al. 2019). All of these resilience processes are shaped by available resources located at the individual, family, community, and environmental levels (Wister et al. 2016).

Previous research has recommended applying the resilience framework to understand specific areas of resilience within different subpopulations of older adults (e.g., based on morbidity, disability, life crises, and/or socioeconomic status) (Wister et al. 2016). Areas of resilience in later life that have been identified for further investigation include (i) psychological resilience; (ii) mobility resilience; (iii) financial resilience; (iv) environmental resilience; (v) physical resilience; (vi) social resilience; and (vii) cultural resilience. This study reviews the extant literature on

mobility resilience, which involves interaction between (i) the attitudes, goals, and motivations of individuals towards mobility and their ability to mobilize and cope with mobility limitations; (ii) the attitudes of family, friends, and the community towards older adults' mobility; (iii) infrastructure, systems, and programs that are integral to accessibility, safety, and overall age-friendliness of the neighbourhood (Wild et al. 2013). The following section briefly reviews evidence on older adults' mobility and the rationale for studying mobility resilience.

Why Study Mobility Resilience?

The concept of mobility in later life is multidimensional and encompasses a wide range of components, including (i) the ability to access desired destinations to maintain familial and social ties and (ii) values, meanings, benefits, and significance (e.g., engaging in physical activity, freedom, choice, autonomy, and independence) (Alsnih & Hensher 2003; Schwanen & Ziegler 2011; Ziegler & Schwanen 2011). Mobility-related decisions have been found to be influenced by the interplay between personal (e.g., biological, cognitive, psychosocial needs and capacities) and environmental contextual factors (e.g., objective and perceived aesthetics, safety, land-use patterns, connectivity and accessibility) (Goins et al. 2015; Yen et al. 2014). Mobility fosters quality of life, physical and psychological health, autonomy, independence, reduced social isolation, social connectedness, and continuity of self and identity among older adults (Byles, et al. 2015; Prohaska, et al. 2011; Rantakokko et al. 2016a, b; Ziegler & Schwanen 2011).

It has been suggested that the maintenance of mobility is particularly important for older adults experiencing mobility difficulties, limitations, and losses due to the associated impact on their health and well-being (Gill et al. 2006; Prohaska et al. 2011). As mobility is multidimensional in nature, the consequences of having mobility limitations are varied and can result in a wide range of physical, social, and psychological negative outcomes, including (i) the likely disruption of meanings associated with being mobile (e.g., feelings of loss of a part of oneself, lowered sense of self or self-confidence and grief); (ii) reduced social participation; and (iii) social isolation and loneliness (Goins et al. 2015; Hirvensalo et al. 2007; Levasseur et al. 2010).

Older adults are likely to respond to acquiring mobility limitations by (i) approaching it with a sense of resignation; (ii) positively reframing their perception of their limitation; or (iii) actively implementing adaptive strategies to cope with their limitation based on the availability of internal or external individual, social, or environmental resources (Goins et al. 2015; Wister et al. 2016). Due to the dynamic and reciprocal nature of P-E interactions, it is possible for older adults to find new ways of interacting with the environment to compensate for mobility-related losses and limitations, which may include (i) modifying aspects of mobility that are within their control; (ii) optimizing physical abilities; and (iii) harnessing untapped potential or cultivating new skills, so as to maintain engagement and participation in meaningful activities (Schwanen & Ziegler 2011; Webber et al. 2010).

Adaptive mobility behaviour, which involves adjustment, modification, and pursuit of goals has important physical, social, and psychological implications for the quality of life of older adults, for example, lower depression, higher life satisfaction, and better health and well-being (Bailly et al. 2016; Goins et al. 2015). Modifying the way in which a task is accomplished lowers the physiological demand on older adults, enabling them to overcome functional limitation, maintain mobility and participation at an optimal level for a longer duration, and prevent mobility decline (Rantakokko et al. 2017). Psychological and physiological resilience have been identified as key moderators in the process of active aging, which encompasses compensation for mobility limitations through the implementation of adaptive strategies (Rantanen et al. 2018). Coping skills serve as a protective factor for resilience among older adults, indicating that the study of coping mechanisms and behaviour falls within the purview of resilience research (Staudinger et al. 1993; Wild et al. 2013).

It is important to adopt a *strength*-based approach [i.e., operating on the belief that there is strength to be found at the level of the individual, as well as within the older adult's interpersonal and contextual spheres (Janssen et al. 2011)] to explore how older adults optimize their capabilities and compensate for losses to sustain mobility and participation in the community (Franke et al. 2013). Previous studies indicate the need to focus on identifying not only the different protective factors associated with resilience but also *how* these factors impart resilience, that is, the adaptive and coping mechanisms through which these factors are harnessed to mitigate the negative outcomes of risk and maintain function and well-being (Ong et al. 2009; Peters et al. (in press); Stainton et al. 2019; Staudinger et al. 1993; Wister et al. 2016). Therefore, this chapter aims to review the literature on the mobility of older adults in the community and highlight the processes of adaptation that older adults with mobility limitations implement to maintain or renew their mobility against age-related losses, thereby building mobility resilience. The research question that guided the review is, *How do older adults with mobility limitations adapt/cope to maintain or improve mobility in-home and in the community?*

Theoretical Framework

Adaptation is a key aspect of the process of resilience given that the latter represents the adaptive relationship between characteristics of the individual and their ecology (Lerner et al. 2012). To examine adaptive processes in mobility through the lens of resilience, the review borrows key concepts from the resilience model proposed by Richardson (2002) and the Lifecourse Multimorbidity Model proposed by Wister et al. (2016). These models define resilience as a process of reintegration that occurs when homeostasis (i.e., state of balance or wholeness that contributes to personal comfort zone) is affected by disruptions due to adversity and stressors. According to

Richardson (2002), the interaction between risk factors and protective factors determines the nature of reintegration, which takes place through the following pathways: (i) *resilient reintegration* (i.e., identifying and/or strengthening resilient qualities through insight from experiencing disruptions); (ii) *reintegration back to homeostasis* (i.e., overcoming disruption only to return to one's comfort zone and not necessarily wanting growth); (iii) *reintegration with loss* (i.e., losing the confidence or motivation to sustain activity and engagement due to disruption); and (iv) *dysfunctional reintegration* (i.e., compensating for the lack of reserves to cope with disruptions through maladaptive behaviour). Wister et al. (2016) emphasize the centrality of harnessing resources and the temporal nature of the adaptive processes that occur over the life course embedded in their resilience model applied to multimorbidity. However, a persisting conceptual gap is the specification of mobility-related processes that foster positive adaptation. The Selective Optimization and Compensation (SOC) model (Baltes & Baltes 1990) has been useful in understanding adaptations to aging-related loss and parallels aspects of the resilience models. In the following sections, we attempt to describe and apply adaptive strategies employed by older adults to foster resilience specific to mobility decline based on the SOC model.

The SOC framework offers a lifespan approach to understanding resilience as a dynamic set of pathways traversing opportunities and limitations that lead to the expression of three integrated adaptive strategies: (i) *selection* (i.e., reduction or avoidance of activities and transforming one's goals), which can be either *elective* (i.e., identifying goals to invest personal resources) or *loss based* (i.e., reprioritizing and restructuring existing goals in response to functional limitations); (ii) *optimization* (i.e., using, refining, and augmenting one's adaptive resources to avoid mobility difficulties through planning, pacing oneself, training, practice, and exercise); and (iii) *compensation* (i.e., using alternative processes to maintain mobility by substituting one activity for another, such as avoiding stairs, and instead, using a ramp or elevator or using assistive devices) (Baltes & Baltes 1990; Freund & Baltes 1998). The SOC model offers a theoretical approach to understanding intentional self-regulation (i.e., the ability to adapt one's physical, cognitive, and emotional behaviour to respond to stimuli from the environment in order to achieve personal goals), which plays an important role in determining the adaptive relationship between the person and the environment, and therefore, reflects resilience (Lerner et al. 2012). The application of the SOC model in this study is timely given that previous research has suggested (i) a potential positive correlation between older adults' resilience and the extent of their adoption of SOC processes (i.e., given by the number of adaptive strategies endorsed) and therefore, (ii) the need to further explore the relationship between older adults' resilience and the application of different SOC strategies to adapt to mobility limitations (Remillard et al. 2019).

Methods

Selection of Studies

The scoping review methodology was considered to be most appropriate for this study for the following reasons: (i) to address the lack of comprehensive review of literature on this topic; (ii) to examine the scope of research conducted on mobility resilience among older adults; and (iii) to identify gaps in existing research and directions for future research (Arksey & O'Malley 2005). Scoping reviews are especially helpful for studies on under-researched topics with a focus on exploring the breadth of related ideas and concepts rather than assessing the quality of the available evidence as they (i) provide a broad overview of the extant evidence on the topic; (ii) identify key concepts that are integral to the topic; and (iii) examine how these concepts are interrelated (Peters et al. 2015).

Initial searches were conducted with the keyword "resilience" along with the following related keywords: "coping," "adaptation," "mobility," "aging," and "community" on the following EBSCO databases: Academic Search Premier, AgeLine, CINAHL, PsycINFO, and MEDLINE. Boolean operators "OR" and "AND" were used to input search terms in the following manner: (resilien*) OR (cop*) OR (adapt*)) AND (mobilit*) AND ((aging) OR (aging) OR (old*) OR (elder*)) AND ((environment*) OR (communit*) OR (neighbourhood) OR (neighborhood). The inclusion criteria for articles to be reviewed were as follows: peer-reviewed; written in English; published during 2000–2019; include participants 55 years of age and above; and focus on mobility resilience (i.e., older adult participants with mobility limitations reporting the use of adaptive strategies to maintain mobility). To find studies that were not identified through this search strategy, additional searches were conducted through the following sources: (i) hand-searching reference lists of screened studies; (ii) inputting following keywords in the Google Scholar database: "falls," "exercise," "mobility," "physical activity," "older adults," "adaptation," and "coping."

Presentation of Results

Data pertaining to the study context, research questions, methodology and methods, sample characteristics, key findings, and limitations were extracted from the selected studies. A narrative summary was developed to present key concepts and results from the reviewed studies and how they relate to the topic of this study, that is, mobility resilience. The extraction and synthesis of findings into key concepts were guided by the SOC model (Baltes & Baltes 1990), the resilience model (Richardson 2002), and the Lifecourse Multimorbidity Model (Wister et al. 2016). Findings

pertaining to different adaptive processes and strategies adopted by older adults to maintain mobility at home or in the community were organized in accordance with the categories of adaptation in the SOC model. Depending on the nature of the strategy adopted, associations were made with different classes of reintegration in the resilience model to characterize resilience-related outcomes.

Results

As shown in Fig. 1, the electronic search of the EBSCO databases returned an initial list of 2399 items following the elimination of duplicate articles. An additional eight articles were identified through subsequent searches (six from hand-searching screened studies and two from the Google Scholar database). Based on the review of titles and abstracts, 76 articles were screened by the first author, while the rest were eliminated for their lack of connection to the topic of mobility resilience. Due to the unavailability of full-text sources for six articles, 70 full-text articles were assessed in detail for eligibility. Of these, 41 were included in the final review as they satisfied the research question of this study, while 29 were eliminated for a lack of emphasis on or relevance for mobility resilience.

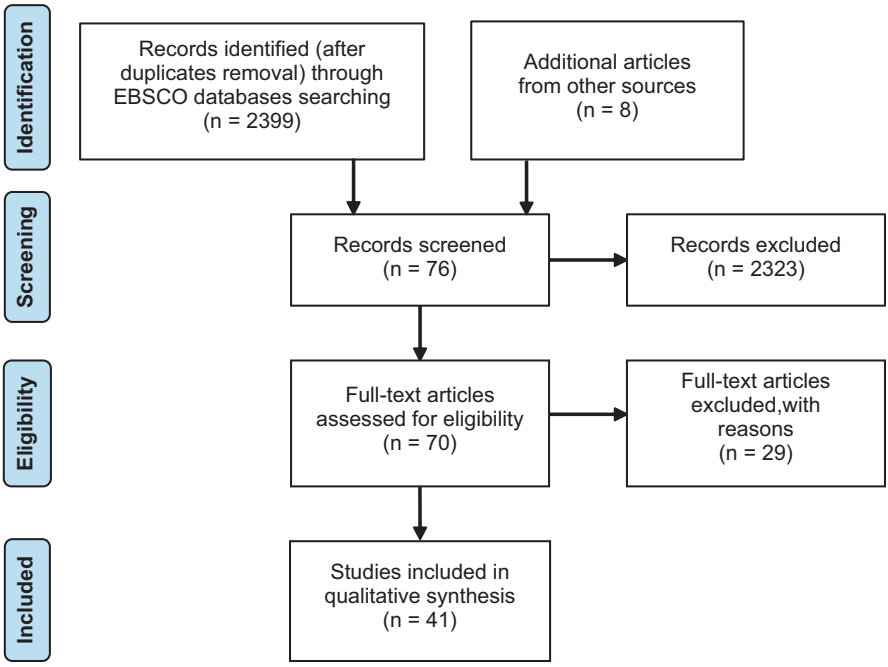

Fig. 1 PRISMA flow diagram – process of selection of studies in the review

Description of Studies

Forty-one studies (see Table 1) were reviewed that were published between 2000 and 2019. Twelve studies were from Canada, 12 studies from the United States, seven studies from Sweden, two studies each from Finland, UK, and Australia, and one study each from Japan, Norway, and Germany. Based on sample characteristics, (i) 17 studies identified participants as having mobility difficulties and functional limitations; (ii) 10 studies identified participants as users of mobility devices, of which 6 focused on power mobility device users and one each focused on users of cane and walker, respectively; (iii) two were based on older drivers; (iv) one identified older adults with the fear of falling; and (v) the remaining studies did not clearly specify mobility limitations. Nineteen studies were quantitative, 18 were qualitative, three used mixed methods, and one was a report of guidelines and recommendations. The sample size varied (i) from 32 (Pettersson et al. 2006) to 5792 participants (Agree et al. 2004) for quantitative studies; (ii) from 3 (Löfqvist et al. 2009) to 81 (May et al. 2010) participants for mixed methods studies; and (iii) from 7 (Brännström et al. 2013) to 127 (Horne et al. 2009) participants for qualitative studies.

The studies reviewed were based on the rationale to expand knowledge on (i) the goals, motivations, decisions, choices, barriers/challenges, and emotions involved in the adaptive processes employed by older adults to cope with and/or bounce back from mobility limitations by fostering mobility resilience (Agree et al. 2004; Aminzadeh and Edwards 2000; Barker et al. 2004; Fristedt et al. 2011; Ganesh et al. 2011; Kamin et al. 2016; Lord et al. 2011); (ii) the meanings attributed to mobility resilience through assistive devices and the pathways of their acceptance (Barker et al. 2004; May et al. 2010); and (iii) the intersectional experience of mobility resilience among groups of vulnerable older adults, for example, women living alone with frailty (Finlayson & Kaufert 2002).

Key Substantive Issues in Mobility Resilience

This section will first briefly discuss factors that influence the adoption of adaptive strategies for maintaining mobility and subsequently discuss various adaptive strategies that emerged from the review of the selected studies. These strategies will be categorized based on the different types described in the SOC framework (Baltes & Baltes 1990).

Table 1 Data chart for studies on mobility resilience of older adults

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
1	Agree et al. (2004)	USA	To identify factors associated with the coping strategies, specifically the use of mobility devices and seeking personal assistance, among older adults experiencing mobility challenges.	Quantitative – Survey	*N* = 5792 Older adults with self-reported mobility challenges	Old-old participants were found to use mobility devices alone. Men were more likely to use mobility devices alone while women were more likely to use them in combination with personal assistance. High education level was associated with combining mobility device use with personal assistance.	Cross-sectional study doesn't allow for causal linkages to be made. Did not distinguish between different kinds of mobility devices. Did not include subjective psychological/cultural factors, e.g., self-efficacy, familiarity with device use, feelings of safety or independence, and cultural attitudes
2	Aminzadeh and Edwards (2000)	Ottawa, Canada	To identify factors associated with cane use among older adults.	Quantitative – Survey	*N* = 106 Older cane users (51) and non-users (55) (age: 65–93 years)	Subjective perceptions were strongly associated with cane use. Older cane users were found to consider the functionality and safety associated with cane use, however non-users perceived it as being inconvenient and unconventional	Lack of generalizability due to the use of non-probability sampling. Cross-sectional study doesn't allow for causal linkages to be made.

(continued)

Table 1 (continued)

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
3	Auger et al. (2010)	Quebec, Canada	To compare the life-space mobility of older adults with mobility impairment using power mobility devices (PMDs) with those who do not use devices and identifying factors associated with greater life-space mobility.	Quantitative – Survey	$N = 116$ Older PMD users at two stages of device usage and non-users (age: 50–89 years)	The life-space mobility of PMD users was better than for non-users. Among PMD users, women have poorer life-space mobility than men. PMD users had more domestic participation objectives, which in turn was associated with greater life-space mobility. Comparing different PMDs, it was found that scooter users have greater life-space mobility than wheelchair users	Data from standardized medical charts did not allow for nuanced and complex characterisation of variables associated with mobility adaptation. Lack of equivalence between the groups of users and non-users.

4	Barker et al. (2004)	Canada	To examine how stroke survivors accept and cope using wheelchairs.	Qualitative – Semi-structured, in-depth interviews	*N* = 10 Older wheelchair (manual and electrically powered) users (age: 70–80 years)	Positive coping resources included positive self-concept, family support, community support, positive attitude, religiousness, perseverance, and staying busy. Three pathways to acceptance of wheelchair use were found: (i) viewing wheelchair as a necessity; (ii) viewing wheelchair as an asset; (iii) considering the wheelchair as a part of one's being.	None stated
5	Brannstorm et al. (2013)	Sweden	To explore meanings of the lived experience of using a walker in daily life.	Qualitative – Narrative interviews	*N* = 7 Older walker-users (age: 79–95 years)	Cane use was associated with feelings of convenience, necessity, safety, confidence, and independence. Participants also perceived the cane as being closely linked to their body and was seen as an extension of oneself.	None stated

(continued)

Table 1 (continued)

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
6	Chee (2013)	Philadelphia, USA	To examine factors that influence environmental and behavioural adaptive strategies.	Quantitative – Survey	$N = 154$ Older adults with functional limitations (age: 70 years and older)	Willingness and readiness to learn and adopt new strategies influenced the success of environmental/ behavioural modification. Older adults living alone were found to be more motivated to adopt behavioural strategies. High level of education was associated with the use of behavioural strategy.	Observer bias

7	Copolillo et al. (2002)	Virginia, USA	To examine decisions made in relation to mobility device use among older adults.	Qualitative – Focus groups and narrative interviews	*N* = 9 Older adults facing difficulties with balance or fear of falling (age: 63–91 years)	Participants reported choosing to delay device use until they are no longer able to manage mobility-related tasks independently. Interim adaptation strategies included seeking support from people and objects in the environment. Participants also reported used devices in combination with support from family. Being around fellow device users helped promote positive self-image and promoted device use.	Observer bias

(continued)

Table 1 (continued)

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
8	Copolillo (2001)	Virginia, USA	To investigate the factors that influence mobility device use among older adults.	Qualitative – Focus groups and narrative interviews	$N = 9$ Older adults facing difficulties with balance or fear of falling (age: 63–91 years)	Acceptance of mobility device is contingent on being convinced of one's need for mobility device support. Participants reported going through several devices before finding the device that best fit their needs and preferences. Length of experience of device use was found to be associated with sense of control and mastery, greater ability to seek assistance from others when needed, and viewing the device as a benefit than a barrier.	Observer bias
9	de Groot and Fagerström (2011)	Norway	To explore older adults' motivations and challenges to maintain group exercise for falls prevention.	Qualitative – Semi-structured interviews	$N = 10$ Older adults with/ without fear of falling (age: 69–85 years)	Adherence to exercise was found to be motivated by the desire to improve balance and ability to walk and maintain physical independence	Recall bias

10	Finlayson and Kaufert (2002)	Winnipeg, Canada	To understand how community-dwelling older women experience community mobility	Qualitative – Semi-structured in-depth interviews	*N* = 23 Older women with independent mobility and limited mobility (age: 69–85 years)	Reduction in travel during certain times of day and poor weather conditions and choosing alternative modes of travel were reported as strategies to cope with mobility challenges.	Recall bias
11	Franke et al. (2013)	Vancouver, Canada	To explore the facilitators of physical activity and mobility for older adults, using a strengths-based perspective,	Qualitative – In-depth interviews	*N* = 23 Physically active older adults (age: 66–88 years)	Resourcefulness, expressed through self-efficacy, self-control, and adaptability, was a faciltator of physical activity. Adaptability among participants was evidenced by adaptive measures, e.g., taking public transportation, pacing oneself, wearing protective gear.	Lack of representativeness of sample
12	Fristedt et al. (2011)	Virginia, USA	To describe older adults' motivations to maintain out-of-home participation.	Qualitative – Focus groups	*N* = 42 20 older men (average age: 81.7 years) and 23 older women drivers/ non=drivers (average age: 79.7 years)	Participants reported using different adaptive strategies to cope with driving cessation, including shortening the duration of outdoor trips, using public transportation,	Issues with representativeness of sample

(continued)

Table 1 (continued)

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
13	Ganesh et al. (2011)	USA	To examine factors that influence in-home mobility of community-dwelling older adults	Quantitative – Survey	*N* = 1002 Older women with self-reported mobility difficulty (age: 65 years and above)	Older adults with the high mobility difficulty are more likely to use mobility devices to cope. The presence of environmental barriers were found to influence the choice of compensatory strategy.	Cross-sectional study doesn't allow for causal linkages to be made. Did not distinguish between older women using mobility devices independently from those who used devices in combination with personal assistance..
14	Gignac and Cott (2000)	Ontario, Canada	To identify older adults' patterns of adaptation and meanings of independence and dependence.	Quantitative – Survey	*N* = 286 Older adults (average age: 68.3 years)	Significant associations were found between optimization in-home mobility strategies and feelings of independence and dependence	Lack of randomization of sample decreased representativeness. Reliance on self-report subjects data to recall bias. Cross-sectional study doesn't allow for causal linkages to be made.

15	Hedberg-Kristensson et al. (2007)	Sweden	To explore older adults' experiences of using mobility assistive devices.	Qualitative – Focus groups	*N* = 22 Older users of assistive devices (age: 65+ years)	The processes of device acceptance, ways of using devices, negotiating environmental barriers, and development of adaptive strategies differ among device users and depend on a range of individual and social factors.	None stated
16	Hendrickson and Mann (2005)	USA	To explore factors associated with change in older drivers' mobility over time.	Quantitative – Survey	*N* = 40 Older adults living with frailty (average age: 78.25 years)	Older drivers who were experiencing driving cessation reported compensating by using alternative modes of transportation and depending on family or friends or neighbours for transport.	Reliance on self-report subjects data to recall bias.
17	Horne et al. (2009)	UK	To investigate older adutls' beliefs about the initiation and maintenance of participation in exercise for falls prevention	Qualitative Participant Observation; Focus groups and Interviews	*N* = 87 focus group participants + 40 interview participants Older users (average age: 64.8 years)	Older adults with perceived fear of falling reported that strength and balance exercise would be beneficial for falls prevention	None stated
18	Kamin et al. (2016)	Nuremberg, Germany	To explore whether in-home accessibility problems are moderated by outdoor motivation.	Quantitative – Survey	*N* = 120 Older adults with functional limitations (age: 59–92 years)	Outdoor motivation was found to buffer the effect of accessibility problems on outdoor mobility.	None stated

(continued)

Table 1 (continued)

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
19	Korotchenko and Hurd Clarke (2016)	Canada	To explore how power mobility device (PMD) users perceive and experience the device use.	Qualitative – Interview	*N* = 29 Older PMD users (age: 51–92 years)	Participants reported a number of ways in which they use PMDs to improve their community engagement. Use of PMDs was found meaningful as it fostered autonomy and independent mobility.	Homogeneous sample limits the representativeness of the data.
20	Laybourne et al. (2011)	UK	To examine predictors of physical activity among older adults at the risk of falling.	Quantitative – Survey	*N* = 22 Older adults (average age: 78.9 years)	Adoption of selection and optimization strategies resulted in improvement in mobility and self-efficacy in relation to falls.	Small sample size. Limitations of case-study approach.
21	Levasseur et al. (2016)	Quebec, Canada	To explore facilitators, barriers, and needs of older drivers with regard to use of adaptive strategies.	Qualitative – Focus groups	*N* = 32 11 older drivers (average age: 76.2 years); 7 family members (average age: 71.7 years); 14 driving professionals	Older drivers reported using a variety of avoidance strategies associated with temporal, weather, and geographic factors, as well as optimization and substitution strategies.	Small sample size of older adults. Lack of representativeness of sample.
22	Lin and Wu (2014)	USA	To investigate the associations between mobility limitations, adoption of adaptation strategies, and dimensions of well-being.	Quantitative – Survey	*N* = 4456 Older adults with mobility limitations (average age: 75.86 years)	The use of assistive devices was positively associated with well-being, however personal assistance was negatively associated.	None stated

23	Loe (2010)	USA	To explore how older women adapt with mobility limitation through the use of assistive technology.	Qualitative – Interviews and participant observation	*N* = 10 Older women (age: 85+ years)	Participants had creative ways of using assistive devices in order to independently perform everyday activities and achieve comfort, confidence, continuity, autonomy, and social connectedness.	None stated
24	Löfqvist et al. (2009)	Sweden	To explore older women's experience of the use of mobility devices (MDs).	Mixed methods – Survey and interview	*N* = 3 Older women users of MDs (age: 85+ years)	MDs were found to satisfy goals associated with occupational performance and participation. MDs were also found to be used in combination with other MDs and served multiple purposes besides supporting mobility.	None stated
25	Löfqvist et al. (2012)	Sweden	To investigate the outcomes associated with the use of power mobility devices (PMDs).	Quantitative – Survey	*N* = 34 Older users of PMDs (average age: 69 years)	PMD use was found to improve mobility and participation, in terms of frequency of outings, easiness, and independence.	Lack of representativeness of sample

(continued)

Table 1 (continued)

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
26	Lord et al. (2011)	Quebec, Canada	To understand how older adults cope with mobility limitations and maintain outdoor mobility.	Qualitative – Interview	*N* = 22 Older adults (age: 62–89 years)	Participants reported adapting outing behaviours by modifying destinations and routes, seeking support from family and friends, and making use of public and community transport services and programs.	None stated
27	May et al. (2010)	Australia	To explore the factors that influence older adults' use of electric mobility-scooters.	Mixed methods – Survey and focus groups	*N* = 66 survey respondents + 15 focus group participants Older users of electric mobility scooters (age: 65+ years)	The use of scooters positively contributed to participants' health and well-being and aided the maintenance of autonomy and control. However, education and awareness of road rules was seen as integral to successfully completing outdoor trips with the scooter.	Small sample size.
28	McAllister (2018)	USA	To identify the best practices with regard to use of canes for older adults.	Case report of guidelines and recommendations	Case report of guidelines and recommendations	The report provides specific recommendations for cane length, tip, and modified techniques of use and grasp.	None stated

29	Pettersson et al. (2012)	Sweden	To explore associations between older adults' adaptations in the home environment with health and well-being.	Mixed methods – Survey and interview	*N* = 4 Older adults with functional limitations (age: 65+ years)	Mobility devices were used in combination with home modifications to facilitate in-home mobility, performance of daily activities, and social interaction.	Lack of generalizability due to small sample size.
30	Pettersson et al. (2006)	Sweden	To explore the influence of power wheelchair use on activity and participation.	Quantitative – Survey	*N* = 32 Older users of power wheelchair (age: 43–85 years)	The use of the powered wheelchair increased participation and facilitated independence, autonomy, social interaction, and community engagement. The duration of device use was found to be positively associated with ability to overcome barriers.	Threat to internal validity due to lack of random selection of participants. Small sample size limits the statistical power.
31	Rantakokko et al. (2016a, b)	Finland	To investigate mobility modification attenuated the risk of mobility difficulty.	Quantitative – Survey	*N* = 848 Older adults with mobility difficulty (average age: 80.6 years)	Mobility modifications were found to attenuat the impact of environmental barriers on mobility difficulties.	Internal validity issues due to self-report.
32	Rantakokko et al. (2017)	Finland	To examine the differences in levels of mobility with relation to mobility difficulty and task modifications.	Quantitative – Survey	*N* = 816 Older adults with/ without mobility difficulty (age: 75–90 years)	Task modifications were associated with higher levels of mobility, and therefore, served as indicators of older adults' maintenance of community participation	Internal validity issues due to self-report.

(continued)

Table 1 (continued)

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
33	Remillard et al. (2019)	USA	To explore the changes in ADL/IADL routines among older adults with long-term mobility impairment.	Qualitative – Structured interview and survey	*N* = 21 Older adults with long-term mobility impairment (age: 52–86 years)	Mobility limitations were found to be overcome through environmental adaptations (e.g., installing ramps and wider doorways)	Limited representativeness of sample; Data was collected only at one time point.
34	Rudman and Durdle (2009)	Canada	To explore older adults with limited vision manage community mobility.	Qualitative – Interview	*N* = 34 Older adults with limited vision (age: 70+ years)	Participants reported practicing (i) selective avoidance strategies involving self-restriction with regard to choice of destinations, time of travel, and mode of transport; (ii) optimizing one's mobility by modifying pace of movement; and (iii) seeking the assistance of others.	None stated
35	Rush et al. (2011)	British Columbia, Canada	To describe the mobility adaptations of older adults to preserve community engagement.	Qualitative – Interview	*N* = 15 Older adults with health conditions (age: 70+ years)	Participants reported using a number of selection, optimization, and compensation strategies to adapt to mobility limitations.	Lack of purposeful sampling according to mobility status.

36	Sawyer and Allman (2010)	USA	To explore the association between mobility resilience and social participation among community-dwelling older adults.	Quantitative – Survey	*N* = 49 Older adults (average age: 75 years)	Significant associations between mobility, social participation, and predictors of mobility resilience were found.	None stated
37	Sutton et al. (2002)	Ontario, Canada	To explore the use of medical assistive devices (ADs) to cope with disabilities and perform mobility-related activities	Quantitative– Survey	*N* = 248 Older adults with osteoarthritis (age: 55–86 years)	Participants reported using both everyday, as well as medical ADs, as well as various selection and optimization strategies to cope with mobility limitations. Everyday ADs were more likely used in the earlier stages of disability, while medical ADs were used when a considerable need was felt.	Lack of generalizability due to convenience sample. Cross-sectional study doesn't allow for causal linkages to be made.
38	Takahashi et al. (2016)	Japan	To explore how older adults cope with incontinence and maintain community participation.	Qualitative – Interview	*N* = 11 Older adults with incontinence (age: 70–90 years)	Participants reported using products to build confidence in managing incontinence, as well as making use of assistive devices and accessible public toilets to maintain outdoor participation.	Limitations of data-set.
39	Thorpe et al. (2006)	USA	To examine the relationship between dog-walking and mobility of older adults.	Quantitative – Survey	*N* = 2533 Older adults with self-reported walking difficulty (age: 71–82 years)	Dog-walkers achieved higher mobility levels than non-dog owners and this pattern was maintained over the long-term.	Unmeasured factors do not allow for further examination of the direction of association.

(continued)

Table 1 (continued)

Study	References	Geographical context	Research questions	Methodology and methods	Sample	Findings	Limitations/issues
40	Winberg et al. (2017)	Sweden	To explore the perception of physical activity among older adults with polio.	Qualitative – Interview	*N* = 15 Older adults with polio (age: 70–90 years)	The use of mobility devices and assistance from family, professionals, and the environment allowed participants to maintain physical activity.	None stated
41	Wong et al. (2017)	Australia	To explore the relationship between older drivers' self-regulation, driving confidence, and cognitive ability.	Quantitative – Survey	*N* = 70 Older drivers (age: 65+ years)	Older drivers with higher cognitive ability were more likely to report driving self-regulation.	Sampling bias affects the representativeness of data.

Selection Strategies for Mobility Resilience

Studies suggest that older adults implement a number of selection strategies to cope with mobility limitations in order to maintain a level of functioning that allows for independent living and/or recovering from mobility decline. Selection strategies implemented by older adults to enhance mobility resilience reported in the literature include (i) avoiding outdoor mobility in the event of weather-associated risks (e.g., ice or snow on surfaces) (Finlayson & Kaufert 2002); (ii) avoiding going to places that are unfamiliar or filled with environmental barriers (Rudman & Durdle 2009); and (iii) minimizing walking levels and the number of activities performed on a given day (Gignac & Cott 2000). Selection strategies implemented by older drivers include (i) minimizing driving distances and (ii) avoiding driving during unfavourable traffic or weather conditions (Fristedt et al. 2011; Levasseur et al. 2016; Rudman and Durdle 2009).

Self-regulation during driving (i.e., reducing the amount of driving or avoiding challenging driving scenarios) is an adaptive strategy that has been found to be positively associated with the driving confidence and driving ability of older adults (Wong et al. 2017). Older adults have reported preferring to drive during the day along familiar routes due to the fear of driving at night and becoming lost and confused (Loe 2010; Lord et al. 2011; Rudman and Durdle 2009; Rush et al. 2011). Since the strategies listed above involve loss-based selection, restriction, and avoidance of activities, adaptation by selection is most likely to result in reintegration with loss for older adults with mobility limitations (Richardson 2002). However, the resultant loss in mobility may not necessarily imply a loss of motivation or hope, but, rather may be understood as a trade-off in an effort to maintain mobility in the longer term by preventing the incidence of potential injury or harm associated with mobility in risky situations. In this regard, selection may be considered a proactive strategy in anticipation of mobility limitations, constraints, or losses (Carstensen et al. 1995).

Previous research suggests that goal adjustment strategies, that is, loss-based selection by older adults to match changes in capacities and available resources, help mitigate the negative impact of limitations or losses on well-being and maintain positive outlook and self-evaluation, self-efficacy, self-esteem, and sense of control in adverse situations (Brandtstädter and Rothermund 2002; Brandtstadter et al. 1993; Rothermund and Brandstädter 2003). The studies in this review suggest that having a positive outlook and high self-control and self-efficacy are protective factors associated with undertaking adaptive mobility behaviour (Franke et al. 2013; Sawyer and Allman 2010). Thus, it may be inferred that loss-based selection to adapt to mobility limitations contributes to mobility resilience among older adults.

Optimization Strategies for Mobility Resilience

Optimization strategies have been found to be associated with higher levels of mobility and physical activity than selection strategies due to self-regulation and restriction (Laybourne et al. 2011). Optimization strategies implemented by older adults reported in the literature include (i) spending more time on planning and preparation for outdoor trips (Gignac and Cott 2000; Rush et al. 2011; Winberg et al. 2017); (ii) organizing trips efficiently to accessible, low-traffic, and proximate locations (Lord et al. 2011); (iii) performing the mobility-related task more slowly and taking rest breaks (Franke et al. 2013; Gignac and Cott 2000; Rantakokko et al. 2016b; Rush et al. 2011); and (iv) wearing protective gear (e.g., hat to reduce glare from the sun, flashlight, running shoes, absorbent products to manage incontinence while outside) (Franke et al. 2013; Takahashi et al. 2016).

Pacing oneself, taking ample rest, and maintaining a balance between comfort and challenge enables older adults to recover and reintegrate from the wear and tear involved in mobility and be prepared for subsequent mobility-related tasks in their daily routine (Rudman and Durdle 2009; Rush et al. 2011; Winberg et al. 2017). Taking part in individual/group exercise or leisure-time physical activity is an optimization strategy reported by older adults with mobility limitations to (i) improve balance and retain control (de Groot and Fagerström 2011); (ii) eliminate pain and stiffness (Gignac and Cott 2000); and (iii) maintain mobility and social participation (de Groot and Fagerström 2011; Winberg et al. 2017). The motivation for initiation and maintenance of strength and balance exercise has been associated with benefits for falls prevention, especially among those who have prior experience of falls and fear of falling (Horne et al. 2009). Optimization of mobility is also likely to occur through the performance of other everyday activities that involve physical activity, for example, dog walking, which results in greater improvement in mobility among walkers than non-dog walkers (Thorpe et al. 2006). Having a car allows older adults with mobility limitations to save time and energy and move between places relatively easily. Older drivers reported coping with decline in driving skills through optimization strategies, such as (i) planning ahead of one's trip and (ii) being cautious while driving (Fristedt et al. 2011; Levasseur et al. 2016; Rudman and Durdle 2009).

Optimization strategies that involve modifying the pace of activity or eliminating pain or stiffness may also lead to reintegration, back to a state of homeostasis, with the goal of restoring comfortability and not pushing one's boundaries to expand the potential for mobility (Richardson 2002). However, some optimization strategies, such as those that involve exercise and physical activity, are conscious efforts made by older adults to boost their mobility performance by stepping outside their comfort zone to obtain a "training effect" (Richardson 2002; Winberg et al. 2017). This is consistent with the notion that resilience is not only an attribute inherent in older adults but also a dynamic process that can be improved through training and practice (Lavretsky 2014). This process of challenging one's abilities for positive

stimulation may result in resilient reintegration due to an initiative to reinforce and strengthen mobility resilience (Richardson 2002).

Compensatory Strategies for Mobility Resilience

This section discusses environmental compensatory strategies that maintain or restore mobility, which can be broadly classified as (i) using alternate modes of transportation; (ii) using physical environmental supports; (iii) using assistive devices; and (iv) receiving personal assistance.

Use of Alternative Modes of Transportation

Using alternative modes of transportation has been found to be beneficial for the maintenance of outdoor mobility and social participation (Hendrickson and Mann 2005). Reliance on public transit and specialized transportation services, especially following the deterioration of driving skills, helps older adults maintain independent outdoor mobility without imposing on family or friends for transportation assistance (Franke et al. 2013; Fristedt et al. 2011; Hendrickson and Mann 2005; Rudman and Durdle 2009; Rush et al. 2011). Prior experience of and willingness to use public transit is integral to overcoming the challenges of driving cessation (Fristedt et al. 2011).

Using Physical Environmental Supports

The physical environment plays an important role in the process of mobility adaptation. Physical environmental characteristics influence the adoption of compensatory mobility strategies in that barriers in the physical environment diminish the effectiveness of compensatory strategies (Ganesh et al. 2011). Taking measures to boost one's knowledge of neighbourhood accessibility and presence of environmental barriers and facilitators [e.g., scooter-users surveying the outdoors while taking public transit to identify roads with well-designed curb-cuts (May et al. 2010) helps older adults, especially those who use assistive devices, to experience greater autonomy and control (Pettersson et al. 2012)]. Older adults have reported using strategies that involve environmental facilitators, including (i) using ramps, elevators, or escalators to avoid using stairs (Gignac and Cott 2000; May et al. 2010); (ii) visiting public destinations with accessible entrances, accessible toilets, and wide aisles (Brännström et al. 2013; May et al. 2010; Takahashi et al. 2016); and (iii) introducing home modifications (e.g., handrails, grab bars, ramps, widening doorways) (Pettersson et al. 2012; Remillard et al. 2019).

Older adults have also reported using everyday objects (e.g., chairs, beds, sofas, railings, counters, walls) in the home environment as part of self-directed adaptive

strategies to delay the adoption of assistive devices (Copolillo et al. 2002; Gignac and Cott 2000; Loe, 2010). Individuals with fewer health needs or mobility limitations are more likely to use everyday objects than those with more complex needs and limitations who tend to favour using assistive devices (Sutton et al. 2002). Older adults with vision impairment are also more likely to use everyday objects in the home environment for mobility support to avoid the complexity of learning to use unfamiliar assistive devices (Ganesh et al. 2011).

Using Mobility Assistive Devices

Assistive devices refer to items that are used to improve and maintain the functional abilities of persons with disabilities and may be manipulated directly by the individual (e.g., walker, cane, wheelchair) or attached to the structure of the home (e.g., stairlifts to access multiple levels in the home) (Gitlin 2009). Older adults who have mobility limitations due to lower-extremity problems and perceive greater environmental barriers are most likely to use assistive devices over other compensatory strategies to enhance mobility resilience (Ganesh et al. 2011; Rantakokko et al. 2016b). Older adults develop creative ways of using assistive devices in ways that are unique to their particular context and often use them in combination with other assistive devices to satisfy different needs (e.g., using a cane to steady oneself at the foot of the staircase and then using a stairlift to go to the floor above) (Loe 2010; Rush et al. 2011). Different mobility devices afford differing levels of mobility and participation, integration or reintegration into group settings, e.g., scooter-using older adults move through a greater area in the neighbourhood than power wheelchair users) (Auger et al. 2010). The device that one used, along with individual participation goals, determined the kinds of activities that older adults could participate in (Auger et al. 2010; Copolillo et al. 2002).

Some of the benefits of using assistive devices for older adults include (i) remaining physically active and mobilize independently with confidence without having to depend on their family for transportation or mobility assistance (Edwards and Mccluskey 2010; Gignac and Cott 2000; Hedberg-Kristensson et al. 2007; Korotchenko and Hurd Clarke 2016; May et al. 2010; Remillard et al. 2019; Sutton et al. 2002; Winberg et al. 2017); (ii) maintaining continuity and engaging in meaningful activities (Barker et al. 2004; Brännström et al. 2013; Edwards and Mccluskey 2010; Korotchenko and Hurd Clarke 2016; May et al. 2010; Pettersson et al. 2006); (iii) enhanced mobility compared to peers who do not use mobility devices (Auger et al. 2010; Davies et al. 2003; Edwards and Mccluskey 2010; Korotchenko and Hurd Clarke 2016; Löfqvist et al. 2012); and (iv) greater positive affect, self-perception, and self-efficacy than non-users (Lin and Wu 2014).

The following sections discuss various protective factors that support mobility resilience via adaptation using a mobility device among older adults, such as (i) decision-making for device use; (ii) competence of device use; (iii) acceptance of device use.

Decision-Making for Use of Assistive Devices

Having full autonomy and control in the decision to use a mobility aid, the level of mobility assistance, and mobility-related decisions (e.g., where and when to go outside) influences (i) older adults' attitudes towards the adoption of mobility aids (Copolillo et al. 2002); (ii) positive adaptation (Copolillo 2001; Gignac and Cott 2000); and (iii) an enhanced sense of well-being (May et al. 2010).

The point in one's disability trajectory at which the use of an assistive device is adopted has been found to be an important factor in building mobility resilience for older adults. Individuals have cited the importance of adopting assistive devices sooner rather than later in order to better maintain their mobility level (May et al. 2010). However, some older adults have reported delaying the use of mobility devices until it is indispensable for the maintenance of mobility due to the social stigma surrounding mobility devices and the pressure to present themselves as capable of independent mobility (Copolillo et al. 2002). Societal norms, expectations, and reception to device use are strongly associated with the decision to use mobility devices (Aminzadeh and Edwards 2000).

Competence of Device Use

The duration of device use of mobility aids is positively associated with personal mastery and control (Copolillo 2001). Longer duration of device use allows individuals to better integrate into society and face challenging situations (Copolillo 2001). The knowledge of traffic rules and mastery of the mobility device in risky locations (e.g., curb-cuts on the sidewalk) are considered essential for the safe use of mobility devices in public spaces (May et al. 2010). Adequate education and training around safe practices and rights of device users have been recommended to ensure that new users are competent and able to safely mobilize in the outdoors (May et al. 2010). Older adults have reported making an effort to optimize their knowledge and use of mobility devices by practising using them within the home environment, which in turn helps build their confidence in device use in the outdoors (Hedberg-Kristensson et al. 2007). Best practice recommendations for cane users include (i) using a long cane fitted with a roller ball tip and (ii) keeping the cane in constant contact with the ground so as to better detect and respond to obstacles and prevent accidents (McAllister 2018).

Acceptance of Device Use

Acceptance has been found to be an important prerequisite for successfully adapting to mobility limitations using assistive devices, and in turn, honing mobility resilience. It involves sequential stages of evolving perceptions of the device, starting with viewing the device as a *necessity*, then as a major *asset* to fulfil the desire for participation and enjoyment, and finally, as a *part of oneself*, that is, a

"substituted body part," in addition to being an asset and necessity (Barker et al. 2004, p. 225; Brännström et al. 2013). The pathway to acceptance of device use is influenced by a number of factors, including (i) taking the time to eliminate apprehension and stigma associated with device use; (ii) fostering positive thought by seeking peer support and learning from others' experience and opinions of device use (Hedberg-Kristensson et al. 2007); (iii) being certain about one's need for an assistive device (Copolillo et al. 2002; Hedberg-Kristensson et al. 2007); and (iv) focusing on the advantages of device use rather than the challenges (Aminzadeh and Edwards 2000). Acceptance also depends on the duration of device use, for example, someone with less experience is likely to appraise device use based on restrictiveness and inconvenience while those with more experience have more positive appraisals (Copolillo et al. 2002; Copolillo 2001). Social acceptance of device use, which contributes to one's self-esteem and positive self-image, is contingent on one's ability to justify device use with a compelling rationale and handle potentially uncomfortable or stigmatizing situations (e.g., others questioning their need for assistive devices) (Copolillo 2001). Internal emotional acceptance of one's mobility limitations and device use even helps older adults expand their personal goals in order to help peers with mobility limitations (Barker et al. 2004). The different stages in the path to acceptance align with the pathways of reintegration in the context of mobility resilience. Accepting assistive devices as a necessity (Barker et al. 2004; Brännström et al. 2013) potentially increases reintegration back to homeostasis, that is, using devices primarily to maintain one's functioning, mobility, and participation (Richardson 2002). On the other hand, viewing and accepting assistive devices as an asset and a part of oneself (Barker et al. 2004; Brännström et al. 2013) would most likely involve personal growth and the development of positive insights about one's resilience, thus resulting in resilient reintegration (Richardson 2002). In this case, older adults intend to use assistive devices to expand their potential for activity and participation within the household as well as in the community.

Receiving Personal Assistance

Older adults with mobility limitations also adapt by seeking the help of friends, family, neighbours, and others in the community (e.g., staff in stores and pharmacies, church members, and healthcare centre staff) (Rudman and Durdle 2009; Rush et al. 2011; Winberg et al. 2017). Social support is deemed a major resource for activating mobility resilience. It has been found that personal assistance from family and community members also acts as reinforcement for the use of assistive devices, especially for those with more severe mobility limitations (Agree et al. 2004; Barker et al. 2004). However, research suggests that non-device users who primarily depend on personal assistance experience lower positive affect, self-perception, and self-efficacy than device-users (Lin and Wu 2014).

Conclusion

The findings from this review shed light on different adaptive processes that foster mobility resilience and help to explain why some individuals can adapt to or recover from mobility limitations better than others. Key factors associated with undertaking adaptive mobility include the motivation to maintain mobility and the willingness to adopt different adaptive strategies, along with traits such as self-control, self-efficacy, and a positive outlook on life, that can assist in reintegration processes. While selection strategies involve restriction of activity due to unfavourable environmental conditions, optimization involves augmenting one's mobility through intentional acts, such as balancing challenge and comfort, pacing oneself, and taking different proactive and protective measures.

The review found a greater amount of evidence on compensatory strategies used by older adults to enhance mobility resilience, which involved the use of alternative means of transportation to reduce reliance on family or friends, supportive environmental features, assistive devices, and personal assistance, which is often received in combination with other forms of support. The use of assistive devices as a compensatory strategy has been well researched. Studies explored different factors that support the adoption and sustenance of device use, including (i) decision-making capacity; (ii) competence and mastery; and (iii) personal, social, and emotional acceptance of device use. It should be noted that although the three types of strategies are discussed separately in this review, in reality, older adults typically respond to adverse situations by invoking the three adaptive processes of selection, optimization, and compensation synergistically, thus resulting in the integrated process of selective optimization with compensation (Baltes and Baltes 1990; Brandtstädter and Rothermund 2002; Freund and Baltes 1998). Combining these adaptive processes is also more likely to result in greater adaptation to mobility limitations and increased mobility resilience (Baltes and Baltes 1990).

These findings suggest that mobility resilience is a multifactorial phenomenon that is achieved through different pathways depending on various contextual factors at the personal and environmental levels and their intersection. The types of adaptive strategies that older adults with mobility limitations employ are explained through the lens of the SOC framework in this review. The actual process of adaptation may be explained as a P-E interaction as per Lawton's (1985) proactivity hypothesis, according to which older adults with higher personal competence are likely to be better at self-regulation, self-directed planned behaviour, and actively changing the environment to suit their needs while those with lower competence are likely more vulnerable to environmental pressure and require higher levels of support. The resilience approach takes this one step forward by offering a more nuanced explanation of adaptation as a transaction between different protective and risk factors in which older adults play a more agentic role. This review illuminates the different forms that this transaction may take to enable older adults to remain mobile and active participants in their community, reinforcing the "dynamic and process-oriented aspect of resilience" (Wister et al. 2016, p. 306). Using a resilience lens

helps to understand potentially fruitful ways that individuals can reintegrate and promote healthy aging.

Limitations

Most studies did not use a random sampling technique and instead used convenience samples, which restricts the generalizability of study findings. Small sample size in several studies compromised the statistical power. Homogeneity of samples in most studies did not account for the diversity of older adults with mobility limitations based on different background characteristics such as race, income level, and ethnicity. Moreover, the majority of the studies were cross-sectional, except for a few longitudinal studies, thereby not allowing for the deduction of a causal relationship between variables. Most of the quantitative studies mostly relied only on self-report measures, as a result of which the data may have been influenced by participants' ability to recall different adaptive strategies.

Research Implications

Resilience, as a phenomenon, occurs at the individual level but within a broader ecological context (Wild et al. 2013; Wister et al. 2016). Therefore, this framework has important implications for understanding and creating mobility resilience at various nested systems within the ecology of aging and is particularly salient to research and practice concerning the development of age-friendly communities. Adopting a resilience-based approach involves focusing on older adults who experience and cope with adversity, which has significant public health implications (Cosco et al. 2017). Understanding how older adults successfully adapt to mobility limitations and other functional difficulties and the factors and processes involved in building mobility resilience can guide the development of programmes that improve and maintain older adults' health and well-being (Peters et al. in press; Sawyer and Allman 2010; Tusaie and Dyer 2004). Viewing mobility loss, adaptation, and acceptance through the lens of resilience, for example, can help healthcare providers suggest appropriate mobility solutions that are tailored to the individual, their psychosocial needs, preferences, and life experience (Barker et al. 2004).

Potential areas of intervention that are likely to benefit from this body of research include (i) implementing environmental modifications with wider range of affordances; (ii) supporting the use of appropriate assistive devices; (iii) creating health promotion programmes that boost older adults' capacities for physical activity; (iv) creating age-friendly networks in the community to provide informal support or assistance; and (v) helping older adults reconcile with mobility limitation and form positive self-concepts in order to be able to cope better (Prohaska et al. 2011). Having policies and programs that help build resilience are likely to promote greater

well-being among older adults by encouraging them to cope with challenges they are likely to face as they age (Cosco et al. 2017).

Recommendations for Future Research

It is important for future studies to expand the knowledge base of resilience-as-a-process across different areas (e.g., mobility, social, community, physical, psychological) and the various levels of the environment (e.g., personal, interpersonal household, neighbourhood, city). With regard to mobility resilience, further research is necessary to better understand how different protective factors (e.g., motivation to remain physically active, supportive features in the built environment) influence older adults' mobility adaptation. Future research could also compare different adaptive strategies for developing mobility resilience and its corresponding protective and risk factors.

Longitudinal research on mobility resilience would likely elucidate how adaptive mechanisms and resilience evolve over time and through the disability trajectory of the older adult, such as positive health behaviours (Wister et al. 2019). Adopting a life course approach could help future research draw associations between individuals' resilience and their life experience, including previous experiences of coping with mobility limitations. Research should also adopt an intersectional approach to account for the effects of immediate and broad contextual factors (e.g., gender, race, ethnicity, culture, and socioeconomic status) on the expression of resilience among older adults. This may be enhanced through the triangulation of qualitative and quantitative longitudinal data analyses.

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Communities and Resilience: Contextual and Collective Resilience

Janine Wiles

Abstract Resilience is a useful and flexible concept for thinking about aging well, but research on this area has tended to focus on individual factors. In this chapter, drawing from research working with older people to define resilience and aging well, I argue that resilience should be considered as a collective, contextual, and participatory process and outcome. In participatory research, we find that older people perceive resilience as an ongoing and negotiated process of balance and emphasise living *with* adversity rather than necessarily overcoming it. Resources and assets for resilience operate at micro or individual, as well as meso and macro levels. The social, physical, and symbolic environments in which older people live contribute to their resilience (and older people contribute to the resilience of the places in which they live). Similarly, we can think about the resilience of groups and communities as well as of individuals. This raises questions about the distribution of adversity and of access to resources for resilience, necessitating we also consider issues around inequities and resilience and how resilience as both process and outcome is different for diverse older people. Fostering collective resilience will require thoughtful collaboration with diverse older people and partnerships across sectors.

Keywords Community resilience · Socio-ecological · Inequality · Participatory · Partnerships

Introduction

Resilience is an attractive concept for thinking about aging, because it recognises the inherent power of individuals to navigate adversity and maintain high levels of well-being (Browne et al. 2009). It helps us to steer a path between, on the one hand, pathology-oriented conceptions of old age as being inevitably a time of decline,

J. Wiles (*)
Social and Community Health, School of Population Health, Faculty of Medical and Health Sciences, The University of Auckland, Auckland, New Zealand
e-mail: j.wiles@auckland.ac.nz

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frailty, and disease or deficit-focused ideas of population aging as an apocalyptic problem (Gutman et al. 2010); and, on the other, overly elitist views about 'successful aging' defined as being minimal to no decline in cognitive or physical function, no disease or illness, and active social engagement (Havighurst 1961; Rowe and Kahn 1997). Each of these approaches is somewhat biomedical and objective and is at odds with most people's subjective experiences of doing well, even in the face of adversity. Studies of lay perceptions of successful aging reveal far more flexible, dynamic ideas about 'success' (Bowling and Dieppe 2005), suggesting that new conceptualisations are needed to fully capture the ways in which older people adapt to adversity. Unlike successful aging, resilience is inclusive; it is an integral part of human experience (Gattuso 2003), which all older adults have the possibility of achieving.

Given that the roots of the concept of resilience originate from psychology and behavioural research and a move against a deficit focus (Masten 2007), there has been a tendency amongst resilience researchers to focus on individualised factors, such as positive emotions, 'grit', or perseverance. The problem with this individualised focus is that not only does it become more likely that we overlook the social and cultural nature of both resilience and adversity, but it also tends to allow us to ignore the inter-related dimensions and contexts that contribute to resilience (Bolton et al. 2016; Grothberg 2003; Wister et al. 2016). In doing so, researchers miss the processes that produce both adversity and resilience, along with the connections with poverty, inequality, and exclusion (Weldrick and Grenier 2018).

In resilience research there has been increasing influence over time from social sciences and from theoretical frameworks such as the social ecology model of resilience (van Kessel 2013). There is also more of a macro focus in research drawing from fields such as economics and disaster studies (Sapountzaki 2014) and a system focus from fields like ecology, economics, engineering, and organisational studies (Connelly et al. 2017). This increasing recognition of the inter-related nature of personal characteristics and environments in the process of resilience is also influencing policy-making. For example, in their report on Healthy Ageing (World Health Organization 2015), the World Health Organisation (WHO) have moved towards a 'capabilities' approach to functional ability and healthy aging, recognising the combination of, and interaction between, intrinsic individual capacity and relevant environmental characteristics in influencing functional ability. Similarly, the age-friendly communities and the dementia-friendly community movements are essentially based around the idea that enhancing built and social environments is fundamentally important to supporting the well-being of older people (Buffel et al. 2018; Fitzgerald and Caro 2014; Golant 2014; Mitchell et al. 2003; World Health Organisation 2007).

Nevertheless, our ability to understand and measure the interactions of people and environment in the resilience process lags behind this work. In part, this is because it is difficult to measure the precise mechanisms and processes by which resilience might work contextually and collectively. Much of the research that does explore the factors or mechanisms that might foster community or contextualised well-being does not necessarily do so under the umbrella of resilience thinking.

Here and elsewhere (Wild et al. 2011; Wiles 2011; Wiles et al. 2012b, 2019a, b; Wiles 2011), we have argued for the need for a critically reflexive, contextualised, and participatory approach to both understanding and promoting resilience, for older people as individuals and for groups and communities that include and are supportive of older people. In this chapter, I draw from our research with older people to argue that rather simply an individual focus, resilience should *also* be considered as a collective and contextual process and outcome, encompassing resources and assets for resilience that operate at the meso, middle level, as well as at personal individual and macro levels. I explore the increasing recognition of (a) context, that the social and physical environments in which people live *matter*; (b) collectivity, the collective resilience of population groups such as communities; and (c) partnership and collaboration, in particular the roles that diverse older people themselves have to play in understanding and contributing to the resilience of older people and the communities they are part of. That is, we should think about both the contributions of communities towards older people's resilience (and vice versa), as well as the resilience of communities or groups of older people.

Resilience and the Environment

Resilience operates both at the level of individual traits and behaviours, *and* in the context of the environments surrounding, and within which a person is embedded. There are three key ideas for thinking about the interaction of environmental contexts and resilience. First, we can consider community resilience as both an *outcome* (i.e. resilient communities or places) and/or as a *process* (e.g. how resources and factors within places and amongst social groups contribute to the ability to manage adversity and challenges and age well). Second, the environment should be considered at micro, meso, and macro levels, all of which interact and intersect. Third, the 'environment' includes physical and material aspects *and* social *and* symbolic or meaning aspects (e.g. the appropriateness of housing, the usefulness of public transport networks to diverse groups including older people).

Physical aspects of our environment include the natural environment and the material things around us. Physical material contributors to resilience might include, for example, high-quality built environments. At a micro level, physical resources for resilience might mean resources for personal physical mobility, or warm and safe housing, and access to a safe household water supply. At a meso level, parks, roads, sidewalks, and the walkability of a neighbourhood may all contribute to this domain, whereas at a macro level, a well-designed and accessible public transport system, excellent publicly funded health services, or access to clean fresh air and water would be considered resources to support resilience, both for individuals and for groups or communities.

Social environments consist of relationships and the institutions that shape our lives. At a micro level, these might include support from family or supportive peer relationships. More broadly social environments contribute to (or detract from)

resilience through things such as opportunities for social connection in communities or good access to culturally relevant social and health services. At the macro level, resilience-promoting social environments for older people would, for example, mean low levels of inequality or opportunities for meaningful participation of older people.

Symbolic or *meaningful* environments are also key. Resources for resilience (and resilience as an outcome) could include the values and attitudes a family, community, or society collectively hold about old age, for example, whether older people are respected and valued or treated as passive and dependent burdens. Similarly, the ideas that a group or society hold about defining health and well-being in older age, or the values that they place on care and relationships, are all potential resources or barriers to older individuals and to older people collectively achieving resilience (Brasche 2008; Ungar 2011).

Physical, social, and symbolic environments all shape each other and constantly interact. For example, the degree to which a society values older people and recognises their contributions and challenges will shape the way they think about addressing social issues, such as isolation and loneliness, or invest resources into housing, green spaces, transport, and the built environment. The degree to which a local environment is walkable or public transport is useful, affordable, and accessible influences the ability of older people to participate meaningfully, which in turn shapes collective views and understandings about old age.

What Do We Learn from Older People About Resilience?

Older people's definitions of 'doing well' tend to be multidimensional, nuanced, contextualised, and attentive to balance and tension (Bauman et al. 2001; Massey et al. 1998). They tend to suggest that developing resilience is possible regardless of social and cultural backgrounds or physical or cognitive impairments (Harris 2008).

In a participatory study of older New Zealanders (aged 65 and older and 55 and older for diverse groups), we examined resilience by means of interviews and participant-led focus groups in two communities: a small town and an urban suburb (see Wiles et al. 2012a). Culturally and socio-economically diverse older people were invited to work with the research team to identify and define resilience in older age. Interestingly, our participants emphasised resilience as an ongoing and negotiated *process* that takes time and changes over time (Wiles et al. 2012a, b; see also Wister et al. 2016), rather than just as an outcome or personal characteristic. What these lay perceptions of resilience also show us is that the assets, protective factors, and resources that support and promote resilience occur at a range of interactive levels and dimensions, from intrinsic individual characteristics and attitudes to collective social and physical environmental characteristics and resources, such as housing and households, neighbourhoods and communities, and societal structures, services, and values (Wiles et al. 2017).

In terms of defining resilience itself, our participants particularly emphasised the importance of balance. For example, many highlighted the tension between striving to be well and to do more, and accepting limitations and adjusting to changes (Wiles 2011). They also pointed to the 'courage' needed to live with age-related change, loss, and vulnerability to the same extent as the importance of 'keeping busy' and 'managing their attitude towards life' (Wiles et al. 2012a, b). A particularly attractive aspect of resilience for many of our participants is the focus on living *with* adversity, challenge, and vulnerability. They emphasised that resilience is about managing, responding to, engaging with, and sometimes overcoming the experience of adversity, rather than avoiding it. They understood resilience as living *with* (not *despite*) challenges and adversity and being able to be well.

Our participants also highlighted different areas and levels of resilience. Resilience and resources in one domain (such as social or cultural or financial capital) might help to overcome stress or lack of resources in another (such as physical health or mobility) (Wild et al. 2011). Resources and assets operate interactively at different levels. For instance, an individual might have few meaningful personal financial assets, but if they live in a society that values distributive justice and the collective and is able to redistribute resources, they may nevertheless be able to use resources that promote their well-being. These might entail at minimum good quality well-designed social housing, appropriate and accessible public transport, or an excellent and equitable healthcare system. Local neighbourhoods or communities may act as resources that contribute to promoting and protecting the resilience of older inhabitants. This is especially the case if the environments have inherent and high levels of social capital and connectedness and provide access to interactive 'third spaces' (such as parks, coffee shops, malls, libraries) that foster opportunities for interactions and contributions (Gardner 2011). These resources often create high levels of walkability and quality physical environments facilitating mobility, physical activity, and recreation. These kinds of local opportunities for participation, interaction, and contributions may even somewhat counter the effects of loneliness, given that families are more geographically dispersed or otherwise engaged (Wiles et al. 2019a, b).

Our research also highlights that achieving resilience (and the resources and assets that contribute to resilience) can look and feel very different for different individuals and groups of people. Geographically, resilience might be variable depending on where people live and the social and physical resources available in different places (e.g. rural compared with smaller and larger urban and suburban environments). Culturally, different values and ideas about dependence and independence, or about autonomy and relationships with family, may lead to quite different ideas about resources and aging well. For example, in our study, older people from some cultural groups valued independence *from* family in terms of getting formal support intimate personal functions while still being able to interact with family. In contrast, others valued family support for intimate personal cares or mobility precisely because it ensured they did *not* have to rely on external formal sources of support (Wiles et al. 2012a, b). Collectively, groups have different experiences of colonisation historically and in the present, including its intergenerational

effects and impact on their ability and expectations of aging well (Brooks-Cleator et al. 2019; Browne et al. 2009). For many, 'resilience' may include the ability to express and respond to difficult emotions (like anger or sadness), when contextually appropriate, but may present to others as 'negative'. That is, 'resilience' does not *and should not* always look and feel like 'happiness' or contentment.

Like research approaches to resilience which focus on individuals, older people in our study (Wiles et al. 2012a, b) tended to begin their definitions by talking about personal characteristics and attitudes and behaviours. However, they quickly moved to more environmental aspects, such as resources in the social and physical environment, and, just as importantly, their ability to *negotiate access* to them. This might include overcoming personal beliefs (such as ideas associated with accepting financial or personal help) or barriers to accessing or using the resources themselves (such as inadequate public transport systems, complicated forms and processes for accessing services or materials, the cultural safety awareness of services providers, or expensive mobility scooters). It is not just the existence of resources in the environment that contributes to resilience but also the ability to negotiate access to them and to convert resources into personally meaningful positive outcomes (Sarre et al. 2014, p. 274; Wiles et al. 2012a, b; Windle 2011).

Much work on the health, success, and even resilience of older people focuses on the services and resources needed to support to older people's well-being. Our research highlighted the need to recognise and celebrate the significant and sustained contributions older people make to the people and places around them (Wiles and Jayasinha 2013). Older people often exhibit a strong sense of place attachment and invest considerable energy and skill in nurturing, advocating for, and working as activists to promote the interests of the people around them and the places in which they live, as well as providing enormous amounts of support through organised voluntary roles (Milligan 2001). Older people in our research contributed in a wide range of ways, from supporting friends and neighbours with advice or transport or practical support to volunteering in formal and informal capacities, advocating for others with government departments or organisations, building a sense of community by connecting with others, or actively lobbying for positive community changes or monitoring quality of services (Wiles and Jayasinha 2013).

The example of loneliness and social isolation illustrates the interconnected nature of scales at which assets and resources for resilience operate, as does resilience itself as an outcome. Older people's experiences of isolation and loneliness are influenced by personal circumstances and characteristics (such as ability to travel, financial resources, closeness to family) and by broader structural factors (availability and accessibility of public transport, intergenerational experiences of colonisation that isolate groups from their cultural resources, social and economic cycles that shape poverty). In our study of social connectedness amongst older people (Morgan et al. 2019), many participants experienced personal mobility issues and constraints on their finances or spoke of experiencing physical and/or social distance from their families, whom they perceived as busy and under pressure

(Morgan et al. 2020). Some groups also spoke of shared personal and collective experiences of overt racism and ageism, for example, from bus drivers or in the media. Participants in general also talked about isolating or transient neighbourhoods or local neighbourhoods where most people are at work all day and neighbours no longer speak or interact easily with each other. Some were members of collectivist cultures, which led to the perception from themselves and others that they *could* or *should* not be lonely. Older people from these groups who nevertheless did experience loneliness were thus even further isolated because of an internal sense of stigmatisation and an external absence of support. Thus, factors that are protective against loneliness (such as opportunities for social interaction or to pursue personal interests) as well as the adversities that produce loneliness and isolation operate in interactive ways that are both immediately personal and more distant and structural (Morgan et al. 2020). This means that interventions to promote social resilience *also* need to operate at micro, meso, and macro levels, recognising that each of these levels interact (Wiles et al. 2019a, b).

Negotiating Access

Equity between individuals and groups is an example of social differences in ability to access and use resources. More privileged groups tend to be able to accumulate, mobilise, leverage, and use resources with such ease that their processes of negotiating access become taken for granted or almost invisible. It thus becomes possible to attribute personal or individual credit for achieving resilience to more privileged older people, who may be thus perceived as achieving it 'on their own'. At the same time, we may implicitly blame those who struggle to achieve resilience or to negotiate access to resources supportive of resilience, ignoring the wide range of underlying economic, political, social, and environmental factors that contribute to the experience of aging well (or not) (Huisman et al. 2017). This is one key reason why thinking about resilience only at the individual level is toxic, because it places both attribution and responsibility for resilience (or lack of it) on individuals and has the potential to exclude those who are marginalised or low income or otherwise do not fit 'norms'.

Focusing on collective resilience in a way that is too generalised or at the macro level, however, creates the risk of further exacerbating inequities and is also potentially toxic. That focus tends to take away the possibility for human agency and courage in the face of adversity, ignoring differential ability to negotiate access to resources for resilience or differential experiences of adversity. A macro focus also tends to lead to one-size-fits-all solutions which typically fail those who are most disadvantaged. Many public health efforts, for example, increase the well-being of those already in privileged situations while not improving (or in the worst cases exacerbating) the adversity faced by the least well-off or most marginalised.

Inequality and Adversity

Thinking about resilience in more collective ways, and about the structural as well as personal aspects of adversity and resilience, also raises the question of relationships between resilience and inequities. While some researchers note those who score highly on traditional resilience measures are typified by having fewer multiple adversities (Hildon et al. 2010), others remind us:

> exposure to adversity is rarely random. The most vulnerable and least endowed people are often most likely to be exposed to adversity [and] have the least resources or assets to successfully cope with adversity.
> (Huisman et al. 2017, p. 577)

Just as adversity is not randomly distributed, the ability to interact with and negotiate access to resources and assets that might enable resilience is neither equally nor randomly distributed. Different groups have different proximity to resources, or resources are appropriate for some groups more than for others (such as the cultural appropriateness of health service delivery or the routing and physical structure of public transport networks). Moreover, in old age particularly, experiences of aging reflect lifelong inequalities, and the cumulative effects of adversity over time, which act to reinforce and amplify adversity (Dannefer 2003; O'Rand 2006).

The concept of resilience as the ability to access resources, or a form of adaptation to living with adversity, becomes especially problematic in the context of groups of older people who are coping with deeply entrenched oppression, injustice, and structural violence. In Aotearoa New Zealand, the Indigenous population, Māori, have experienced the impacts of colonisation over centuries. This includes deeply rooted social inequities fuelled and exacerbated by loss of land and access to vital resources and disconnection from language and cultural values. These ruptures have been historically enforced through the legal and education systems and exacerbated by wider economic structural conditions that pushed and drew people away from their homes to look for work in cities. For older Māori, and for other older people who have lived with grinding poverty and ongoing un- and underemployment as part of the capitalist system, this raises the issue of adaptation in resilience research. Objective measures of resilience can easily tend to focus on a very conservative approach to maintaining 'normal' trajectories of development and tend to value social competence and compliance over expressions of personal agency and critique (Massey et al. 1998). This privileges adaptation that results in people 'fitting in' to pre-existing structures, rather than challenging those structures. At what point do 'normalised' trajectories of resilience become *accommodation* of structural violence and injustice? And at what point do we recognise expressions of outrage and resistance as a form of resilience? Massey et al. (1998, p. 339) maintain that for the concept of resilience to be useful to critical theorists, we must first recognise ideas like the development of 'critical consciousness' or 'becoming aware of one's position in an oppressive hierarchy' as important and valuable ways to respond to risk and adversity. These responses must be considered as aspects of resilience.

Thinking about collective and contextualised community resilience thus raises some critical questions. It is essential to recognise and celebrate the resilience of groups and individuals who are marginalised and minoritised by the mainstream and to highlight the role of culture as a resource and asset for resilience. A growing body of work demonstrates how access to and preservation and practice of traditional cultural customs and protocols, language, and values and resources are protective and promoting of health and well-being, even in the context of other adversities (e.g. Brooks-Cleator et al. 2019; Dyall et al. 2014; Pomeroy 2016; Teng et al. 2019). For example, work with Māori whānau (extended family) providing care to an ill family member at the end of life shows how even when caring took place against a background of poverty, racism, and a lack of health literacy affecting access to resources, cultural values established a resilient foundation for whanau (Moeke-Maxwell et al. 2014). This work shows how values such as aroha (love), manaakitanga (hospitality and caring), and receiving and sharing fortified the dying and their whānau and provided a sense of belonging and a meaningful way of engaging with illness, death, and bereavement (ibid). However at the same time, we also need to recognise, and redress, the structural injustices and oppressions that caused the adversity in the first place (economic, social, colonial, cultural). We also need to better understand the role that social difference and inequality play in limiting or enabling access to resources for resilience (Huisman et al. 2017).

Understanding and Fostering Collective Resilience

Thinking about ways to foster collective resilience *might* thus be a way to understand and address inequities and injustice. Certainly, research and decision-making on resilience should prioritise identifying and amplifying protective resources and assets that may increase the resilience of vulnerable groups specifically. Decisions that enable the redistribution of wealth and the prevention of poverty, such as funding and allocation of public services and pensions, publicly funded housing, and market levers that affect the availability and quality of housing, all have the possibility to enhance resilience of communities and older individuals. So do resources such as community and health support services and good communication and information (Brooks-Cleator et al. 2019; Buffel et al. 2018). Collective and meso-macro level strategies such as these are likely to be more effective and a more efficient way to invest resources than focusing only on how to enhance individual personality characteristics or family attributes (Seccombe 2002).

Arguably the most effective way to address collective resilience is to listen to and work with older people themselves, particularly diverse groups of older people. This participatory approach strengthens the ability to work collaboratively to foster community and collective resilience (Arnstein 1969; Buffel 2018; Dizon et al. 2019; Higginbottom and Liamputtong 2015; Israel et al. 2005; Salmon 2007). This means working across and between sectors (housing, welfare, social inclusion) and across and between levels of government (local, federal, municipal, provincial) to build

upon and enhance what is already there. To successfully achieve community resilience particularly for older vulnerable people, and to develop communities that contribute to the resilience of older people as groups and individuals, it is necessary to engage in meaningful partnerships with those who are most directly affected and most vulnerable (Dizon et al. 2019).

This may mean finding new ways of working to work with the diverse groups of older people who tend to be least visible and heard least in public policy consultations; business as usual is not likely to work. Instead, appropriate cultural engagement, and careful work to understand the most appropriate ways and places and times in which to engage with and listen to diverse groups of older people, will be needed. This will require partnering and investing in people with the right skill sets, as well as strong leadership and the resources (e.g. financial, legislative), to make meaningful change happen. Older people who are age, gender, ethnicity, sexual identity, geographically, and class diverse, amongst other intersecting aspects of difference, need to be engaged as experts in identifying areas of need and opportunities for growth and support. It is these diverse groups who are well-placed to recognise the strength-based opportunities that are embedded in their communities and potential for resources in the larger macro spheres. Specifically, it is they who can best prioritise key issues, problems, and solutions, particularly where the ability to age well intersects with other forms of difference and inequalities.

A strength-based, local emphasis is most likely to be effective, but as well as putting diverse older people's voices at the forefront, this will require partnerships across sectors and with all levels of government working with NGOs and not-for-profits and the social enterprise movement. These partnerships will need to work out ways to harness their respective strengths and perspectives to ensure older people have meaningful access to services and resources at all levels from their homes to the meso level of community and the macro level of regions and beyond. This means physical and social access to services, but also care and attention to the way services are presented and interpreted. If efforts to engage older people do not take account of the diversity of older people, and the diverse cultural and social spaces in which they could and should be engaged, patterns of exclusion will simply be recreated and exacerbated. A critically reflexive, contextualised, and participatory approach to understanding and promoting resilience thus means constantly seeking ways to acknowledge the power of older people to control their lives. It means recognising and addressing ways to identify and redress the contextual and structural factors that create adversity and identifying and enhancing access to and quality of environmental resources to support aging well.

In this chapter, I have offered several ways to think about resilience and community or resilience as contextualised and collective as well as individual. Resources for resilience operate not just at the level of individual characteristics, behaviours, and attitudes but also in the environments within which individuals interact. We can think of these environments as physical, social, and symbolic and as operating at micro, meso, and macro levels; all of these interact dynamically, as processes over time. Simultaneously, instead of only focusing on the resilience of individuals, we can also think about the resilience of groups and communities. Like individuals, a

resilient community is more likely to be able to 'do well' even in the context of changes to the economy, or experiences of poverty, for example, by connecting to cultural or social values. Resilient individuals may contribute to the resilience of a community or group, and vice versa; the resilience of a group or community may be supportive of the individuals within it. We also need to be mindful that some groups experience a greater share of adversity than others and that these differences are not randomly distributed. Noticing this reminds us that 'resilience,' as both process and outcome, may be quite different for different social and cultural groups. This points to the need for participatory and collaborative mindsets in terms of both understanding, addressing, and promoting resilience; resilience work should be done in collaboration and partnership with communities of older people and between different sectors of government and non-government organisations. Understanding resilience as focused on individuals (or indeed solely on communities) creates the potential for the concept to become an unproductive tool, either victim-blaming or agency-erasing. Yet when understood in this more dynamic, complex system of contextualised individual and collective interaction within complex environments, the concept of resilience becomes both more powerful and more amenable to intervention at multiple levels.

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Advancing the Concept of Resilience for Older Adults Who Are Experiencing Homelessness

Sarah L. Canham, Mei Lan Fang, and Mineko Wada

Abstract Current conceptualizations of resilience are ambiguous with neither consensus on the definition nor agreement on how resilience is measured and experienced across populations and subgroups. Moreover, guidance on how to further enhance understandings of resilience and expand resilience research and policy applied to vulnerable groups of aging persons is in its infancy. For example, existing definitions of resilience have overlooked the lived experiences of homeless older adults—individuals who have much to offer in terms of progressing notions on how some people "stand up" to adversity and "bounce back" to a state of physical and psychological homeostasis across the life course. To address this gap in the empirical literature, we use data from a community-engaged research project, which examined the health supports needed for individuals experiencing homelessness upon hospital discharge, to develop a conceptual model of resilience pertinent to homeless older adults. We offer a brief overview of existing conceptualizations of resilience, followed by a description of late-life resilience that focuses on cumulative adaptive capability across different temporal locations. Subsequently, we provide a comparison of resilience among homeless individuals generally and homeless older adults, in order to identify unique characteristics of resilience. Finally, based on narratives of significant adversity experienced by homeless older adults while accessing (or attempting to access) healthcare in Vancouver, Canada, we offer a critical analysis of "resilience in ecological context" operationalized by successive

S. L. Canham (*)
College of Social Work, The University of Utah, Salt Lake City, UT, USA

College of Architecture and Planning, The University of Utah, Salt Lake City, UT, USA
e-mail: sarah.canham@utah.edu

M. L. Fang
School of Nursing and Health Sciences, University of Dundee, Dundee, UK

School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, Edinburgh, UK
e-mail: m.l.fang@dundee.ac.uk

M. Wada
STAR Institute, Simon Fraser University, Vancouver, BC, Canada
e-mail: mineko_wada@sfu.ca

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levels of human development across micro-, meso-, exo-, and macro-systems. A conceptual model is developed based on reported adversities and challenges articulated in a sample of homeless individuals, which can be used to shape research, policy, and practice.

Keywords Resilience · Aging · Homelessness · Conceptual model · Relocation · Ecological

Introduction

Current conceptualizations of resilience are ambiguous, lacking consensus on a single definition and measurement that can be applied across populations and subgroups (Greenberg et al. 2019; Shaikh and Kauppi 2010; Smith and Hayslip 2012). Examination of resilience and aging among specific groups can further enhance understandings and applications of resilience research and policy. For example, existing definitions of resilience have overlooked the lived experiences of homeless older adults—individuals who have much to offer in terms of progressing notions on how some people "stand up" to adversity and "bounce back" to a state of physical and psychological homeostasis across the life course (Windle 2011). To address this gap in the empirical literature, we use data from a community-engaged research project, which examined the health supports needed for individuals experiencing homelessness upon hospital discharge. Based on review of ecological theories and their application to our analysis, we develop a conceptual model of resilience that is inclusive and thus pertinent to homeless older adults (Fig. 1).

Our resilience and homelessness conceptual development is framed by Bronfenbrenner's (1977) ecological theory and expands upon several existing models of resilience (Aldwin and Igarashi 2012; Li et al. 2018; Wild et al. 2013). A strengths-based perspective coupled with an ecological lens is adopted in order to highlight the importance of agency and empowerment for developing coping skills and adaptive capacity (Saleebey 2009). We therefore simultaneously utilize a broad systems approach to understanding an individual's resilience across their immediate environments and settings, as well as across larger socio-structural and sociocultural contexts (Bronfenbrenner 1977). In the case of homelessness, we aim to develop conceptualizations of resilience by elucidating the intricacies emergent within and across micro-systems, meso-systems, exo-systems, and macro-systems, which conjoin to shape resilient homeless experiences across time and place. It is contended that a holistic understanding of resilience requires an examination of "multi-person systems of interaction not limited to a single setting and must take into account aspects of the environment beyond the immediate situation containing the subject" (Bronfenbrenner 1977, p. 514).

We begin this chapter with an overview of existing conceptualizations of resilience and follow with a description of late-life resilience that focuses on cumulative

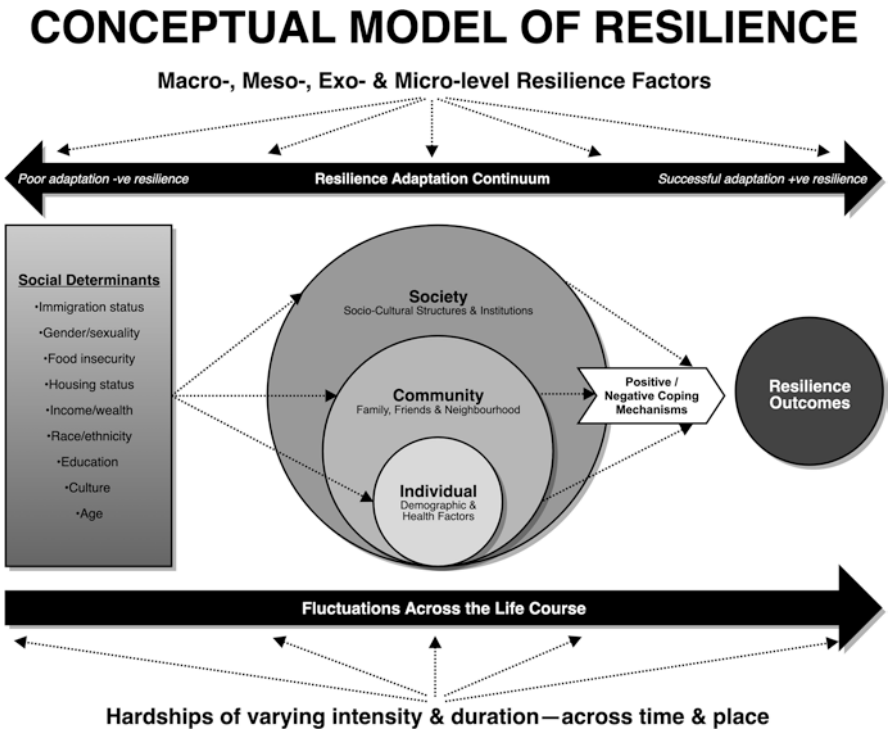

Fig. 1 Presents a multi-system conceptualization of resilience across time and place

adaptive capability across different temporal locations relevant to homelessness experiences. Subsequently, a comparison of resilience among homeless individuals and homeless older adults is provided. This is followed by a critical analysis of "resilience in ecological context" operationalized by successive levels of human development across micro-, meso-, exo-, and macro-systems.

Resilience Definitions and Contexts

Resilience has been differentially defined based on the population under study and adversity context. However, most definitions share the notion that resilience connotes the ability to "bounce back" following hardship (Bolton et al. 2016; Manning and Bouchard 2020; Seccombe 2002). Inherent in conceptualizations of resilience are understandings that individuals do more than just survive in the face of adverse and traumatic life experiences—they thrive (Durbin et al. 2019). For instance, resilience has been likened to "post-traumatic growth" whereby adversarial experiences result in greater psychological functioning (Seery et al. 2010). Resilience is acknowledged as multifaceted and fluid; and thus, individuals can be resilient in

some aspects of their life or during certain life stages, but less so in other circumstances or times (Wild et al. 2013). For example, as Wild et al. (2013) suggest, an individual can be considered socially but not necessarily emotionally resilient. Moreover, developmental theorists understand resilience not as a static characteristic of an individual, but as a process that develops over time and can be fluid (Aldwin and Igarashi 2012; Staudinger et al. 1993). The recognition of the influence of time on individual resilience highlights the importance of taking a multilevel, life course perspective (Wister et al. 2016).

Applying a life course perspective for theorizing resilience not only allows for the recognition that aging is a lifelong process influenced by earlier life events and experiences (Grenier and Phillipson 2013) but also points to the understanding that human agency fluctuates according to micro-, meso-, exo-, and macro-systems over time and that such dynamic interactions between the agency and the systems collectively inform experiences and trajectories of resilience (Wister et al. 2016). Hence, a life course perspective acknowledges the potential for the development of resilience as a consequence of cumulative adversity (Dannefer 2020). For instance, there is evidence of a "dose-response relationship" between exposure to adversity and the development of resilience, whereby exposure to moderate adversity has greater benefits for resiliency than having never been exposed to adversity (Seery et al. 2010). Conversely, highly adverse encounters beyond this seemingly ambiguous threshold offer little or no benefit for developing resilience yet instead becomes an overwhelming experience (Seery et al. 2010).

Despite general agreement that resilience is a concept that signifies triumph in the face of adversity, the nature, domains, and manifestation of this concept have been contested across disciplines (Aldwin and Igarashi 2012; Smith-Osborne and Bolton 2013). With roots in psychology and psychiatry, early conceptualizations of resilience focused on individual-level factors that promoted or inhibited resilience, including an individual's competence and strengths associated with personality characteristics (Masten 2007; Seccombe 2002; Wild et al. 2013). Critiques of individual-level understandings of resilience suggest that, at best, this narrow focus is insufficient (Seccombe 2002) and, at worst, leads to neoliberal ideologies of individual responsibility and victim blaming (Sandy 2014; Sapountzaki 2007; Wild et al. 2013; Wiles et al. 2019). Instead, more recent conceptualizations acknowledge that individuals exist within broader environments and socio-cultural structures and that varying contexts and resources contribute to (or detract from) situational and relational resiliency (Aldwin and Igarashi 2012; Bolton et al. 2016; Seccombe 2002; Wild et al. 2013). With these two camps ("individual resilience" vs. "community resilience") largely independent of and separate from one another, cohesive theoretical developments in the field have been slow to emerge (Wild et al. 2013).

Building from initial theorizations of individual resilience, the interdependence between individuals and the social and structural contexts in which they are situated has been highlighted. Aldwin and Igarashi's (2012) ecological model of late-life resilience portrays the interaction between older adults and the community resources an older adult can draw upon to adapt to or cope with challenges (i.e., the immediate social and physical environment and broader socio-cultural and institutional

structures and policies). Based on this transactional perspective, a mutual, bidirectional influence between individual and community resilience is recognized (Sapountzaki 2007). For instance, older adults have been identified as significant contributors to the development and maintenance of community resilience (Wild et al. 2013). At the same time, community characteristics (i.e., policies, resources) can result in individual vulnerability or inequity as the resilience and privilege of some is strengthened at the expense of others (Sapountzaki 2007; Seccombe 2002). In an environment with limited resources, coupled with structural, historical, and economic inequities, some individuals will be better positioned to harness resources and express resilience than others.

Late-Life Resilience

While significant research has focused on the resilience of children (Zolkoski and Bullock 2012), a notable and growing body of literature has investigated the resourcefulness and resilience of older adults (van Kessel 2013; Whitson et al. 2015). Table 1 summarizes conceptualizations of resilience and factors identified as contributing to resilience among three groups of individuals: general populations of older adults, individuals experiencing homelessness, and older adults experiencing homelessness. As outlined in Table 1, existing research on resilience in later life acknowledges that general older adult populations are resilient when confronted with late-life challenges and losses, including chronic illness, functional decline, mental health, and the death of loved ones (Wiles et al. 2019). Older adults not only experience new adversities in later life, but many individuals enter late life with past experiences of trauma, childhood abuse, or lifelong poverty (Padgett et al. 2012; Seccombe 2002). Despite the acute and chronic challenges and adversity of later life, it has been argued that older adults have had more opportunity than younger persons to determine how to navigate adverse events and develop resilient capacity and coping strategies (Manning and Bouchard 2020; Staudinger et al. 1993).

The literature has highlighted the adaptive capacity of older adults as well as individual- and community-level resources that can contribute to older adults' resilience (Levasseur et al. 2017; Manning and Bouchard 2020). For instance, research with older adults has found that both internal (individual) factors (e.g., memories, sense of self, resourcefulness, and lived experience) and external (interpersonal, socio-structural, and socio-cultural) factors (e.g., social support, living environments, health services, and cultural resources) contribute to agency and adaptation and thus foster resilience in the face of challenges (Manning and Bouchard 2020; Wiles et al. 2019). Aligned with research on selective optimization with compensation (see Baltes and Baltes 1990), which suggests that older adults choose particular goals that optimize the opportunity to age well, several studies have highlighted the repositioning or strategic ways in which resilient older adults negotiate challenges and setbacks (Finlay et al. 2020; Wiles et al. 2019). For instance, as functional decline has the potential to reduce an older adult's ability to engage in their favorite

Table 1 Existing and new contributions to the conceptualization of resilience among older adults experiencing homelessness

Population	Conceptualizations of resilience	Factors of resilience			
		Individual (micro)	Interpersonal (meso)	Socio-structural (exo)	Socio-cultural (macro)
Overview based on existing literature					
General older adult population Research related to: Health conditions Functional decline Trauma Life events Poverty/financial issues	Life course perspective: Older adults have developed resilience and resourcefulness over the life course following adversity (too much adversity has negative impacts) The ability to "bounce back" following hardship and thrive in the face of adverse and traumatic life experiences Increased psychological functioning through posttraumatic growth Fluid, multifaceted, dynamic concept (e.g., more resilience in some life aspects or stages than others) Bidirectional influence between individual and environment factors	Adaptive capacity (via coping styles, memories, sense of self, resourcefulness, experience, selective optimization with compensation) Meaningfulness, sense of purpose, and spirituality Grit and determination Positive perspective (optimism, maintaining hope, humor, and joy) Experience with hardship Mental and physical self-care Independence and control Self-acceptance Altruism Sense of community belonging	Informal social support networks (e.g., family, friends, neighbors)	Formal health and social supports and services (unequal access) Community resources and public services Policies (e.g., income support, housing) and laws	Socio-cultural beliefs and ideologies Cultural notions of age

Population	Conceptualizations of resilience	Factors of resilience			
		Individual (micro)	Interpersonal (meso)	Socio-structural (exo)	Socio-cultural (macro)
Individuals experiencing homelessness Research related to: High rates of chronic and acute illness, mental illness, and substance use disorders Fractured social networks and relationships Stigma Life events		Altruism Compassion Creativity Resourcefulness Coping skills		Formal health and social supports and services (unequal access) Community resources (availability of and access to)	Social perceptions of homelessness, mental health, substance use, and poverty Trauma-informed practice Strengths-based care
Older adults experiencing homelessness Research related to: Unique attributes of older adults who are experiencing homelessness		Strength, hope, spirituality, and faith Acquired wisdom Identity management (reject labels) Self-identify as caring and nurturing			Social perceptions of homelessness, mental health, substance use, and poverty Trauma-informed practice Strengths-based care

(continued)

Table 1 (continued)

Population	Conceptualizations of resilience	Factors of resilience			
		Individual (micro)	Interpersonal (meso)	Socio-structural (exo)	Socio-cultural (macro)
Contributions offered by CBPR study					
Older adults experiencing homelessness Research related to: Poverty/financial issues Cognitive challenges Substance use and dependence Trust issues (financial abuse) Needs for mobility, ADL and IADL assistance Isolation Stigma Episodic adversity	Multilevel, life course perspective that takes a balanced view of resilience to acknowledge the strengths of individuals, communities, and socio-cultural environments that fluctuates across time and place	"Inner strength" Motivation for and attitude toward treatment adherence Self-direction and determination Inclusive decision-making process (engage homeless older adults)—empowerment	Harnessing formal supports from trusted service providers (i.e., social workers, hospital staff, transportation programs, Native counselors) and informal support networks (i.e., children, neighbors, homeless peers) Supportive housing and in-home services (e.g., housekeeping and meal prep)	Shelter environment accessible for those with mobility challenges Available, affordable, and appropriate housing Living environment offers autonomy, dignity, security, and privacy Continuity of community resources that meet complex health needs (availability of and access to) Operational policies (e.g., open hours, harm reduction)	

hobby (e.g., sewing), another activity (e.g., gardening or volunteering) could be assigned increased value. This form of situational adaptation involves contemplation and subsequent modification of one's beliefs about "what is important in life" followed by a process of reprioritization (Baltes and Baltes 1990; Finlay et al. 2020).

Research on late-life resilience has also pointed to the disparity in external resources among older adults, which invariably affect opportunities for resilience. For instance, public services, government-sponsored income support programs, housing policies, and laws differentially affect citizens. Accordingly, decisions that shape these aspects of community living could result in social and health inequalities and inequities, which present notable unjust differences in opportunities across groups (Graham 2007; Seccombe 2002). Such policies and unequal access to resources impact one's ability to negotiate agency within structures and thus shape experiences of resilience.

Related ecological theories have been applied to adaptation to (aging) physical environments among older adults. For example, an older adults' ability to age-in-place or age-in-the-*right*-place (as Golant (2015) has proposed) with increasing age-related vulnerability is affected by both internal (i.e., individual) and external (i.e., interpersonal, socio-structural, socio-cultural) resources. Importantly, not only do adults get older, but so do physical structures, including homes and community infrastructure (Fang et al. 2018a; Sixsmith et al. 2017). In order to age-in-the-*right*-place, older adults may require home modification or adaptation to prevent isolation (Aldwin and Igarashi 2012), while neighborhood infrastructure may require renewal efforts. As Aldwin and Igarashi (2012) note, the contextual intersections of poverty, poor health, limited access to informal social networks and formal services, and rural environments create potential barriers for adapting to the environment.

Acknowledging the multifaceted nature of resilience, a recent qualitative interpretive meta-synthesis conducted by Bolton et al. (2016) identified 9 themes from 12 studies on resilience protective factors among older adults, including (1) access to external social connections, (2) meaningfulness and spirituality, (3) grit and determination, (4) optimistic outlook, (5) previous experience with hardship, (6) mental and physical self-care, (7) independence and control, (8) self-acceptance, and (9) altruism. Complementing Bolton et al.'s identification of altruism and generativity as protective factors, Aldwin and Igarashi (2012) have suggested that compassion and role-modeling to individuals and communities is associated with late-life wisdom and resilience. The theme of grit is associated with perseverance and determination, including the will to survive and refusal of defeat, while self-acceptance encompasses acceptance that one is aging (Bolton et al. 2016). Related, independence and self-care highlight the individual-level of some protective factors and have been supported in subsequent research which emphasizes personal control as important to older adults' resilience (Li et al. 2018; Manning and Bouchard 2020; Wiles et al. 2019). Moreover, optimism and having a positive outlook have recently been found to promote resilience in older Chinese immigrants (Li et al. 2018) and other general population samples of older adults (Manning and Bouchard 2020). Previous hardships (e.g., loss, loneliness, abuse) have been cited by others as creating opportunities to gain skills and perspective in confronting subsequent adversity

(Aldwin and Igarashi 2012; Seery et al. 2010). Finally, research has also highlighted formal and informal social networks as factors in older adults' resilience (Aldwin and Igarashi 2012; Levasseur et al. 2017; Li et al. 2018).

Within these varying conceptualizations of resilience among older adults, there is appreciation for the different, intersectional experiences of resilience and negotiation processes individuals formulate with the socio-cultural system in which they are situated (Sixsmith et al. 2019). As such, the meaning of resilience is subjective across the heterogeneous population of older adults, and more in-depth understandings of resiliency across various older adult subgroups are needed (Wister et al., 2016). Thus, resilience for persons experiencing homelessness is very different than for housed individuals. Our discussion now turns to the limited research on resilience among adults experiencing homelessness (Donaldson et al. 2009) and the even more limited literature on *older adults* experiencing homelessness, which are further outlined in Table 1.

Resilience Among Individuals Who Are Experiencing Homelessness

Similar to research with general population samples, individual, interpersonal, socio-structural, and socio-cultural factors are indicated as important to resilience for persons experiencing stress related to homelessness (see Table 1). Arguably, developing resilience and strong coping resources is more important for persons experiencing homelessness compared to those who are housed. Compared to general populations, persons experiencing homelessness have higher rates of chronic and acute physical and mental illness and substance use disorders (Hauff and Secor-Turner 2014; van Laere et al. 2009; Zerger 2006) and more fractured social networks and relationships (Pauly et al. 2011). Indeed, homelessness itself contributes to these negative outcomes, exacerbating access to health and social care and poor health outcomes (National Health Care for the Homeless Council 2011; Zlotnick et al. 2013). In addition, the stigmatizing treatment of individuals experiencing homelessness by healthcare professionals further contributes to negative experiences (Canham et al. 2019b).

Several sources of resilience for persons experiencing homelessness have been recognized, including individual-level factors of altruism, compassion, creativity, and resourcefulness (McClendon and Lane 2014). Moreover, strong support networks have been identified as important to coping with stress and building resilience (Donaldson et al. 2009; Durbin et al. 2019; Goering et al. 2011), including informal networks of homeless peers who share resources and information (McClendon and Lane 2014), particularly during crises (Donaldson et al. 2009). Social support among persons experiencing homelessness has also been identified as important during transitions into housing or shelter, which are especially vulnerable periods in individuals' lives (Canham et al. 2019b; Durbin et al. 2019).

Resilience Among Older Adults Who Are Experiencing Homelessness

While protective factors and adversities unique to older adults have been a significant focus of the resilience research to date, less attention has been given to understanding the resilience and processes of adaptation among older adults who experience homelessness. For instance, in a meta-synthesis of protective factors for resilience among older adults, none of the studies examined older adults experiencing housing insecurity or homelessness (Bolton et al. 2016), but, rather, focused on general populations of older adults and older adults who had experienced discrimination based on their gender or race. Even in research that has examined resilience among homeless persons, explicit consideration of older adults has been neglected (McClendon and Lane 2014). While some research has focused on resilient communities following natural disasters (e.g., hurricanes, flooding) (Bakkensen, et al. 2016; Cutter et al. 2008; Park et al. 2013), including a burgeoning field of resilience of older adults in these situations (Merdjanoff et al. 2018; Tuohy and Stephens 2012), the resilience of homeless older adults remains absent from these discussions.

One exception to the limited research on resilience among homeless older adults is a recent qualitative interpretive meta-synthesis on the experience of homelessness (Murphy and Eghaneyan 2018) that found coping mechanisms and survival behaviors to be important to the lived experience of homeless older adults (see Grenier et al. 2016). This research on the experiences of older adults living in shelters or on the street found that "resilience, strength, and hope" emerged from participants' reports (Grenier et al. 2016, p. 467). Specifically, homeless older adults reportedly need to be resilient in order to survive while living on the street. Table 1 presents individual and socio-cultural factors that previous research suggests as influencing resilience among homeless older adults. Amidst the vulnerability and challenge of street life, participants in this study expressed hope and described lessons learned and having gained wisdom through their experiences (Grenier et al. 2016). Aldwin and Igarashi (2012) have also highlighted wisdom as an integral element in their ecological model of late-life resilience. Homeless older adults have reported managing age-related physical, psychological, social, and existential symptoms through wisdom that they have acquired over their lives (Bazari et al. 2018). An additional resilience factor described in a sample of older women experiencing homelessness includes identity management through the rejection of the labels of "homeless" and "old" and the distancing of oneself from these associations (Gonyea and Melekis 2017). Instead, self-identifying as a nurturing and caring person, which includes caring for homeless peers, provided these older women with a sense of self-worth (Gonyea and Melekis 2017). Finally, Washington et al. (2009) found spirituality and faith to significantly contribute to the resilience of older African American women as they transitioned out of homelessness.

Conceptualizing Resilience Among Older Adults Who Are Experiencing Homelessness

A recognition of the interdependence between individuals and their socio-cultural environments, as well as the unique vulnerabilities and adversities faced by older adults who are experiencing homelessness, is needed. To begin these efforts, we have developed a conceptual model (Fig. 1) informed by the ecological theory and data from a community-based participatory research (CBPR) study on the hospital discharge experience of homeless individuals. This is particularly timely in light of the need for a strengths-based resilience approach to empower individuals to develop coping skills (Hopper et al. 2010) in the face of housing insecurity in later life. While significant research has identified challenges related to the housing experiences of older adults (Canham et al. 2018a), our conceptual model proposes a more balanced view by highlighting the range of individual strengths and abilities to invoke coping mechanisms (such as informal and formal resources) across interpersonal, socio-structural, and socio-cultural levels that have been influenced by social determinants. Similarly, with increasing emphasis on the need to move away from a biomedical model that focuses on pathology to incorporate strengths in the adaptive capacity of older adults (Bolton et al. 2016; Li et al. 2018), our model unifies earlier resilience models developed in reference to older adults (Aldwin and Igarashi 2012; Li et al. 2018; Wild et al. 2013) by recognizing that resilience is variable across an individual's life and can fluctuate over time in response to different episodic adversities. Moreover, in borrowing from Bronfenbrenner (1977), our model understands an individual as embedded within a community encompassing their immediate and extended family and formal and informal social networks, as well as a broader socio-structural and socio-cultural systems of institutions and policies that influence their lived experience. Finally, the outcomes of coping and adaptation are understood as having the potential to be positive or negative—some people may flourish or adapt well in response to certain adversities or during certain times, while others might do less well and experience negative mental health and well-being. In essence, although varying resilience outcomes are determined by social factors, they are subsequently governed by the coping mechanisms that people use in the face of adversity, including older adults who are experiencing homelessness.

Resilience in Ecological Context

As a first step toward an evidence base for our proposed model, we now turn to the presentation of findings from a CBPR study that assessed the needs of people experiencing homelessness who are transitioning from the hospital to shelter/housing. CBPR is a methodology that has shown promise for enabling collaborative working, particularly in complex projects (e.g., participatory, action-oriented, people-centered

research) that require input and participation from diverse stakeholder groups (Jagosh et al. 2015). This methodology enabled the prioritization of seldom heard voices constituting older adults' experiences of homelessness—information that is less accessible through other data collection methods (Canham et al. 2018a, b). CBPR provides marginalized groups with a voice in the research process, often through participation on the research team, and enables a more nuanced understanding of topics of importance to older adults experiencing homelessness and their lived experiences. Though some research has used qualitative methods to understand resilience among subgroups of older adults (see Bolton et al. 2016), little research on resilience in later life has taken a CBPR approach, with some exceptions (Fang et al. 2018b).

Between October 2017 and January 2018, in-depth interviews were conducted with 10 shelter/housing providers, 10 hospital-based social workers who work closely with homeless populations, and 20 persons with lived experience of homelessness in Metro Vancouver. The study's purpose was to gain an understanding of the needs and gaps in supporting the health of people who are experiencing homelessness as they transition from the hospital to shelter/housing. Indeed, the needs of persons experiencing homelessness upon hospital discharge are distinct from housed individuals who can continue post-acute rest and recovery in their homes (Canham et al. 2019b; Oran et al. 2013). A full description of the study methods are described elsewhere (Canham et al. 2019a, 2020). Through this community-engaged research, narratives of significant adversity were shared by those who directly experienced homelessness while accessing (or attempting to access) healthcare, as well as by those who provide support to persons without a fixed address at the time of hospital discharge—from both within the hospital and in community settings, including shelters or other transitional housing locations. Amidst the adversity and challenge reported, there were noteworthy reports of individual and community resilience, which inform our resilience framework. The contributions to the resilience literature based on this CBPR study have been outlined in Table 1 and are described here in detail.

Micro-system: Individual-Level Resilience Factors

A micro-system is made up of an individual (including individual-level resilience factors) and their immediate environment (Bronfenbrenner 1977). In the case of homeless individuals, environments might include places that lack permanence, such as streets, temporary shelters, parks, couches, and hospital rooms, while individual personality traits, physical/mental health, and demographic factors (e.g., age, education, income, race/ethnicity, gender/sexuality, immigration status, housing status) constitute individual-level factors to be considered. Of note here, individuals are recognized as having the capacity to have resilience in some aspects of their life or during certain life stages, but less so in other circumstances or times (Wild et al. 2013). Moreover, individuals can respond to stress with positive coping strategies

(e.g., problem-focused coping) or negative ones (e.g., substance use self-medication) (Canham and Mauro 2016; Livingston et al. 2012; Mauro et al. 2015) which will affect their adaptation.

Participants in our CBPR study described themselves or the homeless older adults they knew as "stoic" and "self-sustaining" when transitioning from the hospital to shelter, which were factors that contributed to their resiliency. Participants with lived experience of homelessness also acknowledged that their personal motivation and attitude were key elements in improving their discharge experiences. For instance, when asked what worked well with his discharge experience following a hip fracture, a 55-year-old man with lived experience of homelessness and HIV stated that nothing worked well except for his "inner strength":

> [It] was tough, but I did it. Yeah, every time one door close, another one close, something just kept being so frustrating. …I had to go to physiotherapy, I had no money for bus fare, didn't have bus tickets, I struggled to do it. I phoned welfare and asked, "How about a bus fare?" I asked them. "No, we don't." With $600 [income per month], trying to survive, paying $400 [a month] for rent, with no hydro [electricity]… So that's the fight. When I was knocked down and I got back up and I was stronger. That's basically it.

Another participant with lived experience described her self-sufficiency and determination as part of what worked well with her hospital discharge:

> What worked well is my ability to figure out what I was doing; because if I didn't know, if I didn't have that ability, I probably would have sat there [at the hospital] a lot longer. I wanted to be discharged; I did not want to be up there for that long.

Aligned with a recent intersectional policy analysis of self-directed care in mental health (Cook et al. 2017), participants' narratives suggested that when care provision is self-directed, it can encourage a sense of autonomy and empowerment among older adults experiencing homelessness, which can promote their resiliency (see Table 1). Having control over healthcare choices empowers individuals and improves the likelihood of treatment adherence and overall well-being (Cook et al. 2017). Rather than assuming what the needs of people experiencing homelessness might be or making decisions on their behalf, it was reported that persons experiencing homelessness should always be empowered to make decisions so they feel invested in their care and discharge plan. Moreover, flexible and accommodating care, which aligns with the philosophy of meeting people "where they are at" in their life, was considered integral to overcoming barriers to care, and supporting homeless patients find appropriate housing following hospital discharge.

Meso-system: Interpersonal Resilience Factors

As an extension of the micro-system, a meso-system is made up of interrelated micro-systems that collectively shape developmental experiences of a person at specific time points over the life course (Bronfenbrenner 1977). This level acknowledges that, over time and place, individuals have varying formal and informal

support networks that contribute to or detract from opportunities for and experiences of resilience.

In the case of our CBPR study, participants highlighted a range of interpersonal factors that contribute to the resilience of older adults experiencing homelessness following hospital discharge, including harnessing formal supports (i.e., social workers, hospital staff, transportation programs, Native counselors) and informal support networks (i.e., children, neighbors, homeless peers) (see Table 1). Formal support, in particular, was highlighted as needed for isolated older adults and those who have fractured relationships with family members (potentially as a result of chronic severe mental illness or substance use disorders). Outreach workers were described as important in helping homeless older adults navigate an uncoordinated system of health and social care services, as well as connect homeless persons to shelter and housing. Hospital-based social workers, too, were considered an important interpersonal support for homeless older adults' ability to access resources across disparate systems of health and social services. A shelter/housing provider noted:

> One thing I found was especially with the seniors, if there's follow-up with the social worker—if I can connect with the social worker regarding this senior who is discharged, there's usually a higher success rate for wherever this person is going because the social worker usually has started a referral.

In addition, participants in our CBPR study noted that, compared to their housed peers, persons with lived experience of homelessness have unique needs following hospital discharge (Canham et al. 2019b), including the need for coordinated ongoing post-acute care, home health, counseling services, and access to prescription medications. The unique challenges and hardships faced by older adults following discharge included complex and chronic health issues, cognitive impairment, dementia, and victimization. One shelter/housing provider stated:

> Some of the clients aren't capable cognitively to—they might be able to live on their own, but they can't organize payments and all that stuff. It's too complicated now for people. So, there's a real gap there. And it's very uncomfortable to help people with their finances because there's so much suspicion around and there is a lot of abuse of seniors in this area…

Supportive housing was commonly identified as having the potential to serve as a source of resilience for homeless older adults following hospital discharge, particular for those who are unable to live independently (see Canham et al. 2019a). Supportive housing is a form of independent housing that offers residents hospitality services, such as housekeeping and meal preparation. While supportive housing does not generally offer personal care, when there is proper care coordination, a home health agency can be brought into an older adult's home to provide services, such as bathing or wound care. Thus, supportive housing models help bridge a gap in the housing continuum between independent living (i.e., with little or no support) and assisted living, which provides hospitality and personal care, and long-term care, which provides a supervised environment for individuals who require complex care (Province of British Columbia, n.d.). Hence, features of supportive housing were reported to be instrumental in keeping formerly homeless individuals housed

and imperative for reinforcing resilience among persons experiencing homelessness, allowing incremental self-readjustments to environmental changes while enabling skill development needed for independent living. Despite the limited options in the region, a shelter/housing participant highlighted the importance of supportive housing:

> I have a gentleman that really should be in supportive housing, and he's got absolutely nobody. He's very hard to understand, he's at risk of falls, and I don't think he's had proper medical treatment. …I've had him as a client for three years… He transitioned from a shelter to temporary housing, and then I found him permanent housing, and then the housing he was in closed down and then I had to move him again and he's functioning, but he really needs supportive housing, and I can't find it.

Exo-system: Socio-structural Contributions to Resilience

Expanding beyond the meso-system, the exo-system integrates both formal and informal social structures that exist external to an individual, but influence both individuals and the settings in which they are situated (Bronfenbrenner 1977). Social structures encompass major institutions (e.g., government policies that shape practice, media outputs that shape culture), which frame communities and ultimately limit or sanction choices of individuals that reside within them. Moreover, different community environments are imbued with different assets and infrastructure (Bronfenbrenner 1977). These socio-structural factors can facilitate or limit access to resources that can serve to supplement an individuals' resilience, including the resilience potential of older adults experiencing homelessness.

Specific to older adults who are discharged into shelter settings, identified hardships included the need for assistance with activities of daily living, instrumental activities of daily living, and mobility. For some older adults, recovery in shelters is challenged by operational policies or environmental design, such as the shelter being closed during daytime hours or not being wheelchair accessible, which can impede resilience. Participants also noted the particular challenge of older adults having to transition from a hospital setting—where they may have stabilized over weeks or months in a clean room, with regular meals, and the opportunity to rest and rebuild strength—to a shelter that has shared bathrooms and bedrooms, with bunk beds or mats. A shelter/housing provider stated:

> The most challenging part is they go from a hospital—somewhere that everything is provided for them—into the shelter… There's minimal support within the shelter setting because of the large number of clients that we do have and the limited services we can provide.

Rare was the report of an individual being discharged to a single room in a shelter that had a private bathroom, though this model of post-acute care for older adults who are experiencing homelessness was highlighted as ideal. Participants with lived experience described the autonomy, dignity, security, and privacy afforded to them in these situations.

Ultimately, however, the largest socio-structural challenge to supporting resilience among persons experiencing homelessness was the lack of appropriate housing in many of the regional municipalities, as summarized by a participant:

> I'm thinking of a particular woman—she was in and out of hospital, schizophrenic. Most of the mental health housing is in Vancouver, Burnaby area, but because we were in [a different municipality] she wasn't allowed to access any of that housing. We were basically told that we would have to put her on the street in Vancouver if she wanted to access mental health housing in that region.

Macro-systems: Socio-cultural Factors of Resilience

Finally, macro-systems constitute broader socio-cultural beliefs and ideologies manifested through everyday customs and practice (Bronfenbrenner 1977). For instance, the ideas of homelessness and the priority (or lack thereof) given to homeless persons in a given society influence how homeless persons in that society are treated. Macro-level factors might involve notions of stigma and discrimination grounded in how society conceives of poverty (Beddoe and Keddell 2016), mental health (Rössler 2016), substance use (Livingston et al. 2012), and homelessness (Weisz and Quinn 2018), which influences how homeless people are treated (e.g., individual responsibility problem versus harm reduction) and how people interact with them in different settings. As described by a provider, and agreed upon by other participants, experiences of structural discrimination during interactions with healthcare services can be traumatic:

> There's a real problem with discrimination at the hospitals. They will release somebody to the street if they have any history of being in a shelter system or if they have an appearance of some sort and they will keep other people for months. It's basically classism. And I'm not kidding about this.

There are, however, alternate conceptions of homelessness held by those who promote trauma-informed care and strengths-based approaches (Arthur et al. 2013; Hopper et al. 2010). Trauma-informed practice prioritizes safety, control, and choice when serving persons who have been traumatized, including persons experiencing homelessness (Arthur et al. 2013). Not only can the experience of homelessness be traumatizing but so too can the pathway into homelessness (e.g., childhood abuse, historical racism). With the goal of reducing symptoms of trauma while facilitating recovery, trauma-informed care delivery focuses on an individual's strengths (Hopper et al. 2010).

Similarly, in terms of resilience, how society perceives resilience and resilient people might be dictated by media portrayals of specific individuals who have overcome significant trials and tribulations across the life course (i.e., those who have *beat cancer* or *survived a tsunami*). As well, conceptions of what is considered "successful" aging are influenced by social ideologies of what constitutes "success" by the dominant culture rather than particular sub-cultures. Based on accepted definitions of "successful aging" that have been developed with consideration of housed

older adults at the forefront, social perception would likely cast older adults experiencing homelessness as "unsuccessful." Moreover, because pathways into homelessness are stereotypically believed to result from an individual's shortcomings and involves "victim" blaming, rather than recognition of how systemic issues function (Weng and Clark 2018), portrayals of homeless older adults have not fit with society's view of resilience. However, using a strengths-based resilience perspective, our model illustrates the distinct aspects of resilience (i.e., self-determination, supportive networks, available and accessible services, and trauma-informed practice) as it pertains to homelessness in later life.

Conceptual Model of Resilience

This chapter contends that the current definitions of resilience are incomplete and non-inclusive of the lived experiences of homeless older adults. To address this shortcoming, a conceptual model of resilience has been developed that incorporates the multilevel experiences of older adults experiencing homelessness (see Fig. 1). Informed by Bronfenbrenner's (1977) ecological theory, this model integrates a systems-based, life course perspective and is grounded in a strengths-based approach to highlight the importance of empowerment for developing coping skills and adaptive capacity. Our model is predicated on the notion that experiences of resilience are intricate and highly complex because they are shaped across micro-, meso-, exo-, and macro-systems that determine where and how individuals are situated on a continuum of "poor resilience adaptation" vs. "successful adaption" or "positive resilience." Micro-level factors are created by socially constructed and socially determined processes, which reflect one's social identity and subsequently, and can influence one's social and health outcomes. Such micro-level processes are both constrained and liberated by broader socio-structural and socio-cultural factors alongside social supports afforded by the community. Combined, the scale of ecological resilience factors can influence individual-level decision-making that pertain to the various coping mechanisms one can use to overcome circumstances of adversity, which ultimately fluctuate across the life course.

Hence, using data from a CBPR project that examined the health supports needed for individuals experiencing homelessness upon hospital discharge, we provide additional context for the model in the case of understanding resilience among older adults experiencing homelessness. For instance, in transitions from the hospital to shelter/housing, individuals who can navigate the health and social care systems or are attached to system navigators have better outcomes than those without these resilience dimensions. This model aims to acknowledge not only the strengths of individuals but also the influence of formal services, informal communities, and socio-cultural structures and institutions on resilience processes and outcomes, suggesting that interventions across multiple levels can foster resilience.

The proposed model has been developed to serve as a starting point for a more comprehensive conceptual framework in housing- and homelessness-related

research, policy, and practice. However, to build upon our initial conceptualization, more research is needed. First, future research should explore both the positive and negative coping strategies of homeless older adults and how these are associated with resilience. Just as some older adults cope with social isolation and loneliness by hoarding (Turner et al. 2010) and others cope more proactively by joining a group (Cattan et al. 2003), the behaviors and coping mechanisms of older adults experiencing homelessness will vary and require different approaches. Some individuals will respond to threats with positive coping strategies, while others will embrace negative coping. Yet, little resilience scholarship has recognized the value in learning from the responses to the severe adversity faced by homeless older adults. In addition, while the model was developed in consideration of the experiences of hospital discharge for homeless older adults in Western Canada, it would be valuable to reflect on this model at an international scale. That is, *how might the socio-cultural context of Western Canada enable or act as a barrier to resilience as compared to other countries and cultures?* Importantly, future research should aim to empower persons experiencing homelessness by engaging them in the research process (Canham 2019).

Conclusions

Our conceptualization of resilience has implications for policy and practice. While recognizing the micro- and meso-level factors of resilience, the exo- and macrosystems that influence the opportunities for homeless older adults' resilience are equally implicated. Policymakers and practitioners must consider how the physical (i.e., built shelter/housing locations in relation to available services and supports), social (i.e., stigma and discrimination directed toward homeless individuals), cultural (i.e., cultural safety as it pertains to diverse service considerations for intersecting cultures of age, homelessness, ethnicity), systemic (i.e., procedural barriers including bureaucracies of paperwork required for relocating clients), and institutional (i.e., structural stigma such as difficulties accessing primary healthcare without an address) aspects of services and other environments impact the older adults for whom they are making decisions or providing care (e.g., in hospitals, shelters). For instance, in regions where affordable housing is severely limited, innovative programs for post-discharge care are needed for homeless older adults who have been found to do poorly in general shelter settings (Canham et al. 2019a). Only when individuals are understood within the environments in which they are embedded can recommendations for appropriate policy and practice be made.

With recognition of the broader social stigma and discrimination against persons experiencing homelessness or struggling with mental health or substance use disorders, *how can practitioners inform their approach to service and care?* As previously recommended (Canham et al. 2019a), there is a need to provide patient-centered training to healthcare providers in order to improve treatment of homeless persons in hospital settings. Developing core competencies around experiences of

homelessness and resilience among older adults could inform the training and education of healthcare professionals.

Similarly, *what policies have been developed without full consideration of the accessibility and availability of housing and support services or appreciation of the socially embedded conceptualizations of homelessness as a personal fault?* For instance, hospital discharge policies have been developed with cost as the primary driver despite challenges that this top-down approach might have for marginalized, low-income patients. When cost considerations outweigh individual considerations, those who have the fewest resources and supports will suffer the consequences. Alternatively, trauma-informed practice with older homeless adults can serve to prioritize safety, control, and choice and build on an individual's strengths (Arthur et al. 2013; Hopper et al. 2010). Using our framework as a guide, we hope that future decisions are made *with* older adults who are experiencing homelessness through systemic empowerment and meaningful social support to enhance their agency and resilience in place.

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