# Multimorbidity Resilience: Conceptual, Theoretical, and Measurement Developments

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**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

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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.
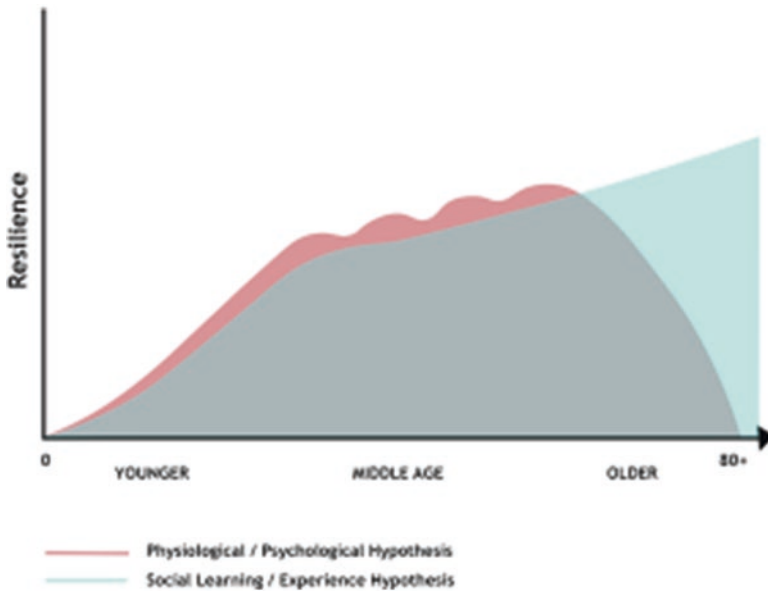
**Fig. 1** Competing resilience and aging hypotheses

## 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 resil-
iency 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 homeo-
stasis, 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 acknowl-
edge temporal aspects of the disruption-recovery nexus, which are especially impor-
tant 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 accumu-
lated 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 multidimen-
sional and dynamic in nature and result from accumulation of life course experi-
ences that are experienced at the later stages of life.

In the LMMR, the individual is concurrently positioned in social and environ-
mental contexts such that resilience experienced at an individual level is connected
to the wider socio-environmental system-level landscape in which individuals inter-
act (Stokols 1992; Connelly et al. 2017). For example, the expression of multimor-
bidity 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
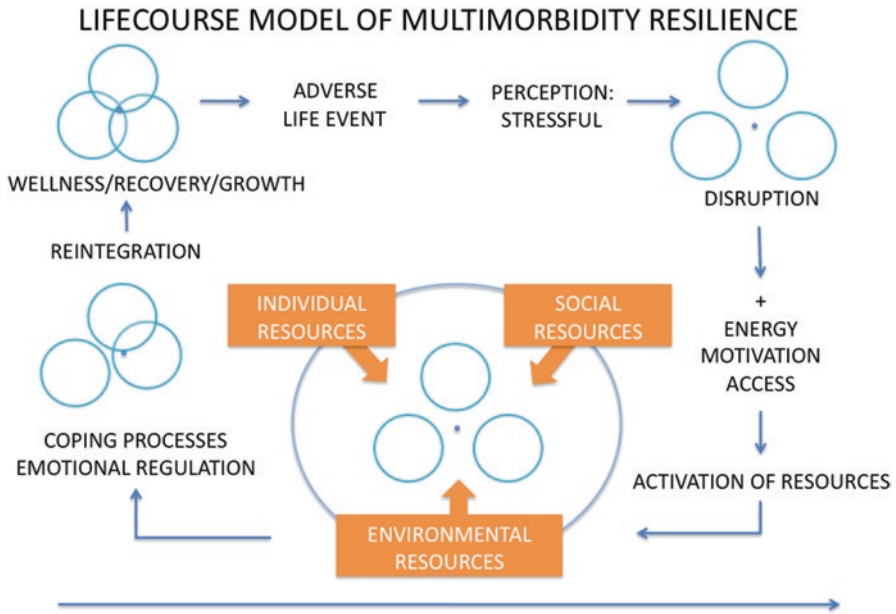
## LIFECOURSE MODEL OF MULTIMORBIDITY RESILIENCE



**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 sub-populations (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 | |

**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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