Urban Sustainability

Ali Cheshmehzangi · Maycon Sedrez · Hang Zhao · Tian Li · Tim Heath · Ayotunde Dawodu *Editors*

Resilience vs Pandemics

Innovations in Public Places and Buildings

Springer

Urban Sustainability

The Urban Sustainability Book Series is a valuable resource for sustainability and urban-related education and research. It offers an inter-disciplinary platform covering all four areas of practice, policy, education, research, and their nexus. The publications in this series are related to critical areas of sustainability, urban studies, planning, and urban geography.

This book series aims to put together cutting-edge research findings linked to the overarching field of urban sustainability. The scope and nature of the topic are broad and interdisciplinary and bring together various associated disciplines from sustainable development, environmental sciences, urbanism, etc. With many advanced research findings in the field, there is a need to put together various discussions and contributions on specific sustainability fields, covering a good range of topics on sustainable development, sustainable urbanism, and urban sustainability. Despite the broad range of issues, we note the importance of practical and policy-oriented directions, extending the literature and directions and pathways towards achieving urban sustainability.

The series will appeal to urbanists, geographers, planners, engineers, architects, governmental authorities, policymakers, researchers of all levels, and to all of those interested in a wide-ranging overview of urban sustainability and its associated fields. The series includes monographs and edited volumes, covering a range of topics under the urban sustainability topic, which can also be used for teaching materials.

Ali Cheshmehzangi · Maycon Sedrez · Hang Zhao ·
Tian Li · Tim Heath · Ayotunde Dawodu
Editors

Resilience vs Pandemics

Innovations in Public Places and Buildings

Springer

Editors
Ali Cheshmehzangi
Qingdao City University
Qingdao, Shandong, China

Network for Education and Research on Peace and Sustainability (NERPS)
Hiroshima University
Hiroshima, Japan

Hang Zhao
University of Nottingham
Ningbo, China

Tim Heath
University of Nottingham
Nottingham, UK

Maycon Sedrez
Deakin University
Geelong, VIC, Australia

Tian Li
University of Nottingham
Ningbo, China

Ayotunde Dawodu
University of Greenwich
London, UK

ISSN 2731-6483 ISSN 2731-6491 (electronic)
Urban Sustainability
ISBN 978-981-99-8671-2 ISBN 978-981-99-8672-9 (eBook)
https://doi.org/10.1007/978-981-99-8672-9

We collectively dedicate this book to our friends and family members who lost their lives or loved ones during the COVID-19 pandemic.

…only if thoughtful actions could have superseded thoughtless inactions!

Acknowledgements

We would like to sincerely thank all authors and contributors for their hard work and dedication in writing their chapters. While we met some of them online in recent months, we hope we get the opportunity to meet all of them in person in the near future. Their support, dedication, and continuous efforts are recognized, genuinely valued and highly appreciated.

Ali Cheshmehzangi acknowledges and appreciates the support from the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT), Toyota Foundation, and the Network for Education and Research on Peace and Sustainability (NERPS) at Hiroshima University, Japan.

About This Book

We recall from our first volume that the COVID-19 pandemic and other highly transmissible disease outbreaks have given a new significance to the concept of '*resilience*', placing it in the spotlight of built environment-related studies. This also includes studies at micro scales of public places and buildings. New directions have emerged from expanding on adaptive planning, urban layouts, urban morphologies, spatial planning, healthy cities, etc. To enhance resilience in the post-pandemic era, various theories, practices and hypotheses are being formulated by scholars around the world.

The second volume of this series delves into the theme of resilience in the post-pandemic era, with a specific focus on ***public places and buildings***. In contrast to the first book, which explored the evolving concept of 'resilience' in the built environment, this volume narrows its scope to the research of the built environment at a smaller scale. This book aims to analyse and discuss the profound changes in architecture and urban design that have risen in response to pressing pandemic-related issues, such as social distancing, air renovation, social behaviour and other relevant topics.

Resilience vs Pandemics: Innovations in Public Places and Buildings explores innovative solutions for architecture and public places during and after the pandemic. Additionally, the authors contribute to the documentation of architectural and social transformations that have been prompted by previous transmissible diseases, as this knowledge can inform responses to future pandemics. In this volume, the chapters present critical, exploratory, multi- and interdisciplinary and cutting-edge research approaches; with a particular focus on the effects of COVID-19 and other highly transmissible diseases on the design, use, performance and perception of the built environment, particularly at the building scale. This volume aims to organize a collection of scientific studies, reviews, analysis, recommendations and solutions in the fields of urban design, architecture, design, landscape design, etc.

The overarching goal is to document new approaches to create and enhance built environment resilience. Chapters shed light on novel methods, tools, processes, regulations, behaviours and other relevant details contributing to a comprehensive

understanding of this crucial issue. The two scales of the built environment under consideration are:

(1) Public Places, including research on transformations (death, emergencies, changes), requirements, adaptability, usability, virtual immersion, historical perspectives, interactivity, shifts in use and programmes, etc.
(2) Buildings, including regulations, shifts in use and programme, non-pharmaceutical interventions, human interactions and human–machine interfaces.

The book covers a wide range of studies, including physical and non-physical studies, which may refer to the city infrastructure, green/blue spaces, housing, policy-making, health services, social and economic issues, etc. The findings and results of various global case study examples contribute to the decision-making of governments, organizations and institutions, as well as inspire scholars and future research for developing resilience in the post-pandemic era.

Target audience of the book is from diverse multi- and interdisciplinary backgrounds, including—but not limited to—scholars, institutions, practitioners and stakeholders performing research and plans in the fields of urban studies, architecture, urbanism, social sciences, computer sciences, history, politics, etc. The target audience recognizes the relevance of resilience in the built environment to achieve more sustainable cities.

Ali Cheshmehzangi
Maycon Sedrez
Hang Zhao
Tian Li
Tim Heath
Ayotunde Dawodu

Contents

Editors and Contributors

About the Editors

Ali Cheshmehzangi is the World's top 2% field leader, recognized by Stanford University. He has over 17 years of academic and practice experience. He leads initiatives in applied research and diligently works on co-creating synergies between academia, industry and government. He is currently in a senior leadership and management role at Qingdao City University where he is a Professor of Architecture and Urban Planning and Director/Head of the Center for Innovation. He previously held several senior, leadership and management roles as Full Professor in Architecture and Urban Design, Head of the Department of Architecture and Built Environment, Founding Director of the Urban Innovation Lab, Founding Director of the International Network for Urban-Rural Research, Director of Center for Sustainable Energy Technologies, Founder and Head of Research Group for Sustainable Built Environment and Interim Director of Digital Design Lab. He was a Visiting Professor and is now a Research Associate of the Network for Education and Research on Peace and Sustainability (NERPS), Hiroshima University, Japan. So far, he has published over 400 journal papers, articles, conference papers and book chapters, with 20 academic books. He is globally known for his research in urban sustainability. He has several award-winning books and has received several scholarly awards for his contribution and impact on higher education, applied research and policy development.

Maycon Sedrez is a Brazilian architect and urban designer, artist and educator with a background in computational design and digital fabrication. His research areas include complexity and architecture, parametric design, digital fabrication, technologies and urbanism. He obtained his Ph.D. Diploma with excellence in Architecture, Technology and City from the University of Campinas in 2016. He contributed to the Institute for Sustainable Urbanism (TU Braunschweig—Germany) as a Postdoc in the field of urban analytics. Later in 2019, he became part of the University of Nottingham Ningbo China's team, leading the Digital Design Lab, and acting as Course Director

and Deputy Head of Department. He is now a Lecturer in Architecture at Deakin University in Australia (2023).

Hang Zhao is a Researcher in the fields of urban planning, design and management. She obtained a Master of Urban Design at the University of Melbourne in 2021. Her professional skills cover city and regional planning, transportation design, landscape architectural design, etc. Now, she is researching resilient cities and built environment at the University of Nottingham, Ningbo Campus, China.

Tian Li is a Researcher who studies resilience-oriented urban planning and management. She has a background in urban and rural planning, urban design and regional analysis and planning. She completed her Master's degree with Distinction in M.Arch. in Sustainable Urban Design at the University of Nottingham, UK. Currently, she is researching at the University of Nottingham Ningbo Campus, China, and her research mainly focuses on pandemic-resilient urban strategies and urban public spaces.

Tim Heath is a qualified architect, town planner and urban design practitioner having worked in the UK for over 30 years and for the past 15 years in China where he has undertaken consultancy and projects related to architecture, urban design and building and urban environmental performance assessments. He is the Course Director of the M.Arch. Sustainable Urban Design and the Director of Postgraduate Programmes. He has previously been the Director of the Institute of Architecture, Head of the School of the Built Environment and, subsequently, Head of the Department of Architecture and Built Environment. He has also been the Associate Dean for Internationalisation and External Relations in the Faculty of Engineering and Acting Vice-Provost for Research and Knowledge Exchange at the University of Nottingham, Ningbo Campus, China. He has also acted as an external examiner in many prestigious universities around the World for undergraduate and postgraduate programmes as well as being a Ph.D. examiner. He has chaired many academic and professional accreditation and validation panels in the UK, Malaysia, China and for the UAE's Commission for Academic Accreditation. He is also a member of the Human Factors Research Group.

Ayotunde Dawodu is a Sustainable Urban Researcher and Energy Engineer with a zeal for developing and implementing sustainable solutions across the urban fields: Waste Management, Transport, Energy (Efficient and Renewable), Spatial planning and Ecology sectors. He is equipped with a B.Sc. in Mechanical Engineering and M.Sc. in Sustainable Energy Engineering, Ph.D. Energy Technologies and Sustainable Development. He also possesses expertise in Sustainable Building Design/Analysis and strongly advocates integrated community participation in urban decision-making and planning. He also specializes in sustainability assessment tool

methods for evaluating guiding, ranking and assessing the sustainability of buildings and communities. He is currently a Senior Lecturer in the Built Environment at the University of Greenwich, UK. He is also a certified BREEAM Assessor, WELL Accredited Professional (AP), and member of the WELL Concept 'Communities' Advisory Group for the International WELL Building Institute (IWBI), further attesting to his professional capabilities as a sustainability and health and well-being expert in the built environment.

Contributors

Kazbek Aitbekov Department of Civil and Environmental Engineering, School of Engineering and Digital Sciences, The Environment & Resource Efficiency Cluster (EREC), Nazarbayev University, Astana, Kazakhstan

Nina Alvandipour School of Public Administration, University of Central Florida, Orlando, USA

Gigliola Ausiello Department of Civil, Building, and Environmental Engineering (DICEA), University of Naples Federico II, Naples, Italy

Egemen Avcu Department of Machine and Metal Technologies, Ford Otosan Ihsaniye Automotive Vocational School, Kocaeli University, Kocaeli, Turkey

Monica Botta Studio Monica Botta, Bellinzago, NO, Italy;
Politecnico di Milano, postgraduate training course "Therapeutic Landscape Design", Milan, MI, Italy

Zengwen Bu Redco Group, Shenzhen, Guangdong, China;
Department of Electronics and Information Engineering, Bozhou University, Bozhou, Anhui, China

Stefano Capolongo Politecnico di Milano, Department ABC – Architecture, Built environment and Construction engineering, Design & Health Lab, Milan, MI, Italy;
Politecnico di Milano, postgraduate training course "Therapeutic Landscape Design", Milan, MI, Italy

Xinhong Cheng Huasen Architecture and Engineering Design Consulting Co., Ltd., Guangzhou, Guangdong, China

Ali Cheshmehzangi School of Architecture, Qingdao City University, Qingdao, China

Ayotunde Dawodu University of Greenwich, London, UK

Lorenzo Diana Department of Civil, Building, and Environmental Engineering (DICEA), University of Naples Federico II, Naples, Italy

Ahmed Ehab School of Design and Creative Arts, Loughborough University, Loughborough, Leicestershire, UK;
Human Factors Research Group, Faculty of Engineering, University of Nottingham, University Park, Nottingham, UK

Marco Gola Politecnico di Milano, Department ABC – Architecture, Built environment and Construction engineering, Design & Health Lab, Milan, MI, Italy

Xiaoqiang Gong Department of Electronics and Information Engineering, Bozhou University, Bozhou, Anhui, China

Mert Guney Department of Civil and Environmental Engineering, School of Engineering and Digital Sciences, The Environment & Resource Efficiency Cluster (EREC), Nazarbayev University, Astana, Kazakhstan

Tim Heath Department of Architecture and Built Environment, Faculty of Engineering, University of Nottingham, Nottingham, UK

Xinglin Jiang Zhubo Design Group Co., Ltd, Shenzhen, Guangdong, China

Ferhat Karaca Department of Civil and Environmental Engineering, School of Engineering and Digital Sciences, The Environment & Resource Efficiency Cluster (EREC), Nazarbayev University, Astana, Kazakhstan

Tian Li University of Nottingham Ningbo China, Ningbo, China

Anna Lisa D'Aniello Varese, VA, Italy

Jian Liu Ecological Technology Institute of Construction Engineering Shenzhen University, Shenzhen, Guangdong, China

Mehdi Nilipour Department of Urban Planning, University of Larestan, Lar, Iran

Osama Omar Associate Professor of Architecture, Department of Architecture and Interior Design, College of Engineering, University of Bahrain, Manama, Bahrain

Francesco Polverino Department of Civil, Building, and Environmental Engineering (DICEA), University of Naples Federico II, Naples, Italy

Samer El Sayary Assistant Professor, Faculty of Architecture - Design and Built Environment, Beirut Arab University, Beirut, Lebanon

Maycon Sedrez Deakin University, Geelong Waterfront, VIC, Australia

Francesco Sommese Department of Civil, Building, and Environmental Engineering (DICEA), University of Naples Federico II, Naples, Italy

Meng Tian Lab for Optimizing Design of Built Environment, School of Architecture and Urban Planning, Shenzhen University, Shenzhen, Guangdong, China

Aidana Tleuken Department of Civil and Environmental Engineering, School of Engineering and Digital Sciences, The Environment & Resource Efficiency Cluster (EREC), Nazarbayev University, Astana, Kazakhstan

Galym Tokazhanov Department of Civil and Environmental Engineering, School of Engineering and Digital Sciences, The Environment & Resource Efficiency Cluster (EREC), Nazarbayev University, Astana, Kazakhstan

Wanheng Yang Shenzhen Cenpoint Architects & Engineers Co., Ltd., Shenzhen, Guangdong, China

Lei Yuan Lab for Optimizing Design of Built Environment, School of Architecture and Urban Planning, Shenzhen University, Shenzhen, Guangdong, China

Hang Zhao University of Nottingham Ningbo China, Ningbo, China

Jishou Zhong China Architectural Design and Research Institute Co., Ltd, Beijing, China

Chapter 1
Space and Resilience

Ali Cheshmehzangi, Maycon Sedrez, Ayotunde Dawodu, Tim Heath, Hang Zhao, and Tian Li

Abstract Despite the World Health Organization no longer classifying the COVID-19 pandemic as an ongoing public health emergency, its enduring impacts on people's lives remain significant. The importance of social distancing and minimizing physical contact has never been more emphasized in society, demanding new approaches to public places and architectural design in order to bolster resilience. Public places and buildings now routinely feature hand sanitizers at their entrances, floor markings to maintain distancing in waiting areas, and signage promoting various social behaviours that were not previously considered necessary. This chapter serves as an introduction to Volume 2 of the book, providing a concise overview of the research context, objectives, and the book's structure. It also introduces the potential role that architecture and urban scholars can play in responding to pandemic conditions. The overarching goal of the book is to deepen our understanding of essential routines, behaviours, and spatial transformations necessary to develop innovative and resilient solutions within the built environment.

Keywords Resilience · Pandemics/epidemics · Innovation · Public places · Architecture · Sustainability

A. Cheshmehzangi (✉)
School of Architecture, Qingdao City University, Qingdao, China
e-mail: ali.chesh@qdc.edu.cn

Network for Education and Research on Peace and Sustainability (NERPS), Hiroshima University, Hiroshima, Japan

M. Sedrez
Deakin University, Geelong, VIC, Australia

A. Dawodu
University of Greenwich, London, UK

T. Heath
University of Nottingham, Nottingham, UK

H. Zhao · T. Li
University of Nottingham Ningbo China, Ningbo, China

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_1

1 Preparing for the Future: Resilience in Pandemics

In 2023, the World Health Organization (WHO) revoked the status of COVID-19 as an ongoing public health emergency, concurrently issuing a warning that the global community must prepare for upcoming infectious diseases (UN News, 2023). During the COVID-19 pandemic, social distancing became a regulator of the use of public places and buildings, and having other health measures also implemented, such as the installation of hand sanitizers and signage to inform new acceptable public behaviours. In fact, social distancing coupled with other nonpharmaceutical interventions was effective in controlling disease spreading (Cheshmehzangi, 2020; Cheshmehzangi et al., 2023a). In this sense, our cities became the primary space for actions to respond to future epidemics' impacts. Because cities need to articulate population growth, urban development, and density with economic growth, sustainable thinking is an integral part of urban governance. It is known that less developed cities may suffer from reduced economic activities, for example, public transport usage during an epidemic event. However, new opportunities for transforming the city and keeping economic activities emerged, such as home-office and building conversions (Mahtta et al., 2022). Again, confirming our rationale in the first book, architects, urban designers and planners must take action to generate innovative ideas for pandemic scenarios (Allam & Jones, 2020).

In this book, the notion of resilience, already addressed in Volume 1, expands to the built environment on a smaller scale: architecture and public place. Resilience has been discussed in architecture for centuries, since Vitruvius published the seminal work *De Architectura* (20-30 BC) defining three pillars for architectural design and design in general: strength, utility, and beauty. Whereas Vitruvius was generally referring to the building stability and resistance to collapse, in recent years, the term gained an expanded relevance due to the increased impacts of natural, social, and man-generated challenges that cities face (Anelli et al., 2022). Still, there are certain gaps to be explored concerning a reconceptualization and application of resilience in architecture and urban design, partly due to the lack of definitions and multiple ways that the term is employed (Hassler & Kohler, 2014).

While architecture and resilience require more investigation and establishing a proper framework, we cannot ignore the numerous solutions that seek to enhance different forms of resilience in architecture and urbanism. An issue with these approaches is that, in general, the research on resilience targets a single problem, for example, public places' resilience to earthquakes (French et al., 2019). This does not take the merit of the research focusing on one specific problem. But in the case of a pandemic outbreak, the interrelation between factors, stakeholders, and environments increases exponentially, challenging researchers to use more comprehensive and systemic methods. We observed the difficulty of correlating multiple factors when analysing mobility and the COVID-19 pandemic (Cheshmehzangi et al., 2021). Another good example is presented by Holmgren (2009). By applying the scenario planning method, Holmgren (2009) provides four scenarios for communities to adapt to the oil crisis and climate change. This approach can potentially

support the envisioning of uncertain epidemic scenarios to create potential responses for communities.

Having these methods and strategies in mind, we invited chapters that improve the significance of resilience in architecture and urbanism under the scope of highly complex health issues that are pandemics and epidemics. Contributing chapters shed light on novel methods, tools, processes, regulations, behaviours, and other relevant details contributing to a comprehensive understanding of this crucial issue. This compilation of innovative research generates a broader understanding of architecture and resilience, informing how architects, designers, planners, urbanists, landscape designers creative thinking can minimize the damaging effects of spreading diseases.

2 The Aim and Objectives of the Book

This book is the second volume of our extended studies related to "*Resilience vs. Pandemics*". In the first volume, we focused on innovations and interventions at the city and neighbourhood scales (Cheshmehzangi et al., 2023b), while this volume covers the other two smaller spatial levels. Thus, Volume 2 delves into the theme of resilience in the post-pandemic era, with a specific focus on 'public places' and 'buildings'. In contrast to the first book, which explored the evolving concept of resilience in the built environment, this volume narrows its scope to the research of the built environment at a smaller scale. This book aims to analyse and discuss the profound changes in architecture and urban design that have risen in response to pressing pandemic-related issues, such as, social distancing, air renovation, social behaviour, and other relevant topics. The two scales of the built environment under consideration cover the main critical conditions caused by pandemics:

(1) **Public Places**: research on transformations (death, emergences, changes), requirements, adaptability, usability, virtual immersion, historical perspectives, interactivity, shifts in use and programs, etc.;
(2) **Buildings**: regulations, shifts in use and program, nonpharmaceutical interventions, human interactions, and human–machine interfaces.

Based on the contributions of chapters at these two scales, the objectives of the book can be concluded as below:

(1) To take a reflective approach to examining the resilience of the built environment amid pandemic contexts. It does so through rigorous scientific investigations that adopt a comprehensive and multi- and interdisciplinary perspective, with a specific focus on both public places and buildings at various scales.
(2) To share valuable insights into how pandemic innovations can be applied in public places and buildings specifically.
(3) To bring together a group of top scholars and researchers highlighting resilient strategies and practices for post-pandemic public places and buildings.

The book covers a wide range of studies, including physical and non-physical studies, which may refer to the city infrastructure, green/blue spaces, housing, policy-making, health services, social and economic issues, etc. The findings and results can contribute to the decision-making of governments, organizations, and institutions, as well as inspire scholars and future research for developing resilience in the post-pandemic era.

3 Structure of the Book

The book is divided into two parts based on the studied scales of the built environment, where Part 1 includes five chapters and Part 2 includes three chapters. The chapters within this book encompass a diverse range of case studies, theoretical research, and targeted policies and strategies. This approach ensures a comprehensive examination, addressing both urban planning and the details of small-scale spaces. Furthermore, including various international cases in the chapters offers a valuable opportunity for cross-cultural reflection. These diverse contexts from different countries can inspire future explorations while simultaneously providing a platform for comparative analysis and extracting valuable lessons from their collective experiences.

This book responds to the call of WHO and aims to prepare for potential opportunities and threats. Therefore, it is arranged based on the studied scales to better cover the comprehensive and multi-context topics. They are (1) Innovations in Public Spaces and (2) Innovations in Buildings.

Part 1: Innovations in Public Places

The first part provides five cases of resilience innovations at the public space scale, including case studies in the UK, Italy, the USA, and Iran, respectively (Chaps. 2–6). The contributing authors discuss the concept of resilience in public spaces by investigating the importance, quality, and accessibility to green spaces to support people's health beyond providing fresh air. They also analysed how tactical urbanism also plays a crucial role in access to dynamic public places. Below is the summary of the five chapters included in this part.

Chapter 2: "Rethinking the design of vertical green spaces in the post-pandemic era: Visitor behaviour and real-life cognitive experience at Crossrail Place, London".

By: Ahmed Ehab, and Tim Heath.

The COVID-19 pandemic has profoundly impacted public spaces in cities worldwide, posing challenges in creating enjoyable, usable, and safe environments in high-density urban areas. Vertical urban spaces, such as roof gardens, have emerged as significant components of cityscapes, offering unique qualities in location, accessibility, and experience. This chapter investigates the Crossrail Place roof garden in Canary Wharf, London, through direct observation and 44 semi-structured interviews

conducted before, during, and after the pandemic. The research explores critical aspects of vertical spaces, including accessibility, circulation, activities, design challenges, security, and safety. Findings highlight human behaviours, areas for improvement, design strategies, and the need for flexible regulation in these spaces. The chapter also examines the potential increased demand for vertical public spaces in the light of future pandemics and travel restrictions. This evidence is crucial for policy makers, urban designers, landscape architects, and government organisations to recognise the importance of vertical urban spaces in future city planning.

Chapter 3: "New green spaces for urban areas: a resilient opportunity for climate change adaptation and urban health".

By: Lorenzo Diana, Francesco Sommese, Gigliola Ausiello, and Francesco Polverino.

The Covid-19 pandemic underlined the positive role of public green spaces for the physical and mental health of citizens forced into long periods of immobility and social distancing. In cities with high population density, these restrictions have underlined the need to increase public green spaces and their accessibility. Indeed, green spaces have the role of improving urban health in terms of mitigating environmental impact, improving air quality, reducing the transmission of diseases, and promoting the psycho-physical well-being of citizens. After analysing the possible Nature-Based Solutions (NBSs) applicable at urban scale and their advantages in terms of urban health, this chapter aims to apply them to public spaces (such as roads and squares) and large public buildings located in the central areas of historic high-density cities. The use of NBSs in the transformation and regeneration of consolidated urban fabrics aims at enhancing their resilience, constituting new public spaces with social purpose, useful even in emergency periods of physical distancing. A new methodological approach is implemented and applied in the compact fabric of the historic city centre of Naples, through two phases: (i) as built analysis, (ii) intervention. Several buildings and public spaces are identified and the readiness to increase accessible and non-accessible green spaces is assessed, to obtain spaces for social use, as well as to mitigate the environmental impact. Pre- and post-intervention results show that non-accessible green spaces are easier to increase through the construction of green roofs, while accessible green spaces that can be used by citizens are more complex. Nevertheless, a significant increase of accessible green spaces is achieved. The application of NBSs in urban areas, is not only a technical strategy, but also a resilient solution, as it can transform some existing spaces into green ones with social value, and improve urban health.

Chapter 4: "How breaks in nature can affect the users' wellbeing: an experience-based survey during the lockdown (COVID-19): Strategies for healthy and resilient green areas in our cities".

By: Marco Gola, Monica Botta, Anna Lisa D'Aniello, and Stefano Capolongo.

In the occasion of COVID-19 pandemic, the life of citizens was greatly disrupted—from healthcare professionals to the smart workers—and consequently also the state

of mood. On the basis of the scientific evidence about the relationship between the built environment and health, a research group has promoted an investigation on the benefits that greenery can have on the psychophysical state of the users, especially healthcare staff and users at home. The methodology adopted is the Profile of Mood States, which provides experiential activity in nature—without any technological distraction- to evaluate the benefits of mood. The methodology adopted refers to the shorter version (34 items) elaborated by prof. Grove at the University of Western Australia. About the COVID-19 pandemic, the experience-based questionnaire was administered to general users in Italy. The questionnaire is composed of a few questions, to be completed before and after an experience in nature of 20/30 min. The investigation requires to be carried out in private gardens, balconies and/or terraces with greenery, public green areas, etc. 225 participants took part in the investigations. Data analysis highlighted the higher performances in anxiety, depression, anger, force, fatigue, and confusion, for users who had the experience in the garden (−50/70%). Although it is well-known the benefits that nature affects positively on well-being and stress level of users, the investigation underlines that a brief break in nature—especially in a period of great stress such as the pandemic—can influence the well-being and mental health of users. The chapter aims to list and suggest some design strategies for a new approach to the design of healthy cities.

Chapter 5: "Tactical Urbanism as an Innovative Urban Governance Tool: Lessons from the COVID-19 Pandemic".

By: Nina Alvandipour.

The COVID-19 pandemic has disproportionately impacted urban communities, particularly those with vulnerable populations, prior inequalities, and poverty. Tactical Urbanism (TU), characterized by short-term, low-cost, scalable interventions with a vision for long-term change, has gained attention as a means of promoting urban resiliency in the built environment. Viewing through the lens of urban governance, this chapter introduces TU as an open and collective innovation ecosystem in the real-life setting that has the potential to tackle some of the long-standing local problems in the post-pandemic era. The chapter provides an overview of TU practice and research by reviewing academic and grey literature, as well as studying various TU examples implemented in public open spaces after the COVID-19 outbreak. The main aim of this study is to understand the factors that have made TU an increasingly relevant and widely used approach in public open space transformation during the COVID-19 pandemic. By examining the driving forces behind its recognition and adoption, we hope to shed light on the potential value of TU as a powerful governance tool for fostering innovation in urban environments. The way that short-term, low-cost, unsanctioned innovations can eventually lead to sanctioned practices demonstrates the importance of TU in enabling bottom-up initiatives to inform top-down processes. Through active participation, experimentation, and co-creation, this approach can help ensure that public space interventions are responsive to the needs of the community, particularly underserved communities. And as a result, it can contribute to the co-creation of more resilient and equitable cities under uncertainty.

Chapter 6: "Urban parks and mental health recovery during the pandemic: Insights from an Iranian case study".

By: Mehdi Nilipour, and Ali Cheshmehzangi.

As a result of the COVID-19 pandemic, urban parks have been highlighted as necessary for cities to cope with the stress of the virus threat and the physical restrictions imposed in response. Public health and urban planning can benefit from examining the associations between urban parks and mental health. The present study aimed to investigate the relationship between Fateh Garden and the mental health of its users. It is vital for public health and urban planning to take into account the associations between parks and mental health. Fateh Garden is the second largest park in Karaj, with an area of 15 ha. This study employed a modified Warwick-Edinburgh Mental Well-being Scale (WEMWBS) to measure the impact of Fateh Garden on users' mental health. Seventy-six of the users filled out the questionnaire. Furthermore, fifty-seven semi-structured interviews composed of 27 males and 30 females were conducted with Fateh Garden users. Participants were asked to rate fourteen items on a 1–5 Likert scale about their mental health. The mean score in this study is 52.12, which is higher than the mean score norms for WEMWBS and shows the high impact of Fateh Garden in improving the mental health of its users. The results also indicated that positive mental health was significantly and positively correlated with Fateh Garden's users' age, marital status, and employment status. This study confirmed a generally beneficial relationship between Fateh Garden and the mental health of its users, especially during the pandemic. Moreover, the present study shows that people choose a park that reminds them of their favourite components and gives them peace of mind.

Part 2: Innovations in Buildings

The second part focuses on the building scale, including the cases from Egypt, China, and Kazakhstan, respectively (Chaps. 7–9). In these three studies, design principles, building standards, and high-touch surfaces are investigated, aiming at a comprehensive discussion about resilience in architecture. The summary of each chapter is presented below.

Chapter 7: "How to Deal with Epidemic Disaster in Buildings: Introduction to the Epidemic Prevention Design Standard of Residential Building".

By: Zengwen Bu, Jishou Zhong, Lei Yuan, Xiaoqiang Gong, Jian Liu, Xinglin Jiang, Xinhong Cheng, Wanheng Yang, and Meng Tian.

The outbreak of COVID-19 has brought new challenges to architectural design: how to reduce the impact of epidemic disasters through architectural design. The paper compared the number of casualties caused by epidemics and geological and meteorological disasters in history, and analyzed the ways of transmission of novel coronavirus and the building response strategies, concluding the necessity and importance of compiling epidemic prevention standards, and suggesting building epidemic prevention standards be taken as one of the basic standards for urban and building

disaster prevention, to provide a safe barrier against epidemic disasters for a higher living environment in the future. And the paper introduced the starting point, positioning and thinking of compiling Epidemic Prevention Design Standard Of Residential Building (T/ASC27-2022), including the general principles, chapter division, epidemic prevention level of building and epidemic prevention design measures of different specialties providing a safe barrier against epidemic disasters when the next epidemic strikes. Finally, the specific case application of the epidemic prevention design of the Qianxihui project in Putian, Fujian Province is elaborated in detail.

Chapter 8: "Impact of high-touch surfaces on potential transmission of diseases in offices and public buildings".

By: Kazbek Aitbekov, Egemen Avcu, Galym Tokazhanov, Aidana Tleuken, Mert Guney, and Ferhat Karaca.

The global pandemic caused by COVID-19 has raised serious concerns regarding the implementation of public health and social measures to prevent infections. The main routes of transmission include direct contact with at-risk patients and indirect contact with contaminated high-touch surfaces. High-touch surfaces (e.g., lift buttons, door handles, tables) are generally accepted as important spots of infection transmission. The present work investigates the transmission dynamics of surfaces in public and office environments via determination of highly touched surfaces. Additionally, self-inoculation in these environments was measured by the average number of hand-to-face contacts. The observation data were collected based on the direct physical contact with touched surfaces where subjects were the members and visitors of each environment. The results indicate that doorknobs and tables can be considered as highly touched surfaces at both investigated sites due to their higher contact frequency. The public environment involved a greater number of contacts per hour than the office environment. Anti-viral materials such as mineral nanocrystals, photocatalyst nanomaterials, and metallic nanoparticles should be chosen for hard surfaces in office environments, including door handles, tables, walls, and doorframes. As an example, Zinc (Zn), magnesium (Mg), and copper (Cu) are among the most prevalent metals that bind with viral proteins. Consequently, anti-viral coatings with intelligent release of Zn, Mg, and/or Cu ions could be developed and used to prevent the viability of SARS-CoV-2 virus on high-touch surfaces. It should be noted that increased human exposure to these ions would require a careful assessment of potential adverse health consequences along with measures targeting their minimization. The presented results provide understanding on transmission dynamics through surfaces in building environments, and ensuing discussion may help contribute to building sustainability and promote pandemic resilience via innovation in the built environment.

Chapter 9: "The Resilience Principles of the Built Environment in Light of Climate Change and the Post-Pandemic Era".

By 9: Ossama Omar, and Samer El Sayary.

The global pandemic caused by COVID-19 has raised serious concerns regarding the implementation of public health and social measures to prevent infections. The main routes of transmission include direct contact with at-risk patients and indirect contact with contaminated high-touch surfaces. High-touch surfaces (e.g., lift buttons, door handles, tables) are generally accepted as important spots of infection transmission. The present work investigates the transmission dynamics of surfaces in public and office environments via determination of highly touched surfaces. Additionally, self-inoculation in these environments was measured by the average number of hand-to-face contacts. The observation data were collected based on the direct physical contact with touched surfaces where subjects were the members and visitors of each environment. The results indicate that doorknobs and tables can be considered as highly touched surfaces at both investigated sites due to their higher contact frequency. The public environment involved a greater number of contacts per hour than the office environment. Anti-viral materials such as mineral nanocrystals, photocatalyst nanomaterials, and metallic nanoparticles should be chosen for hard surfaces in office environments, including door handles, tables, walls, and doorframes. As an example, Zinc (Zn), magnesium (Mg), and copper (Cu) are among the most prevalent metals that bind with viral proteins. Consequently, anti-viral coatings with intelligent release of Zn, Mg, and/or Cu ions could be developed and used to prevent the viability of SARS-CoV-2 virus on high-touch surfaces. It should be noted that increased human exposure to these ions would require a careful assessment of potential adverse health consequences along with measures targeting their minimization. The presented results provide understanding on transmission dynamics through surfaces in building environments, and ensuing discussion may help contribute to building sustainability and promote pandemic resilience via innovation in the built environment.

Lastly, the closing chapter, titled “Towards Resilient Public Places and Buildings to Pandemics”, serves as a summary chapter (Chap. 10). It extracts key lessons from previous chapters and points out new directions of built environment resilience studies in the post-pandemic era. It highlights the possibilities of resilient solutions and summaries each chapter’s key ideas and contributions.

Sustainability is a broad concept encompassing resilience, a promising research field in architecture and urbanism. The United Nations Sustainable Development Goals help to create a pathway for nations and cities to achieve a better future. However, methods to employ resilience and systems to evaluate its effects still need development. This represents an opportunity for built environment researchers to collaborate with governments and create innovative responses to the SDGs. We believe that the COVID-19 pandemic forced many transformations in a short period of time, challenging our preparedness for such an undesirable scenario. Notwithstanding this unexpected situation, these chapters help to unveil what are the possible actions to be considered in the future.

References

Allam, Z., & Jones, D. S. (2020). Pandemic stricken cities on lockdown. Where are our planning and design professionals [now, then and into the future]? *Land Use Policy*, *97*. https://doi.org/10.1016/j.landusepol.2020.104805

Anelli, D., Tajani, F., & Ranieri, R. (2022). Urban resilience against natural disasters: Mapping the risk with an innovative indicators-based assessment approach. *Journal of Cleaner Production, 371*. https://doi.org/10.1016/j.jclepro.2022.133496

Cheshmehzangi, A. (2020). *The city in need: Urban resilience and city management in disruptive disease outbreak events.* Springer.

Cheshmehzangi, A., Sedrez, M., Ren, J., Kong, D., Shen, Y., Bao, S., Xu, J., Su, Z., & Dawodu, A. (2021). The effect of mobility on the spread of COVID-19 in light of regional differences in the European Union. *Sustainability, 13*(10), 5395. https://doi.org/10.3390/su13105395

Cheshmehzangi, A., Su, Z., Jin, R., Dawodu, A., Sedrez, M., Ardakani, S. P., & Zou, T. (2023a). Space and social distancing in managing and preventing COVID-19 community spread: An overview. *Heliyon, 9*(3), e13879. https://doi.org/10.1016/j.heliyon.2023.e13879

Cheshmehzangi, A., Sedrez, M., Zhao, H., Li, T., Heath, T., & Dawodu, A. (Eds.). (2023b). *Resilience vs. pandemics: Innovations in cities and neighbourhoods.* Springer.

French, E. L., Birchall, S. J., Landman, K., & Brown, R. D. (2019). Designing public open space to support seismic resilience: A systematic review. *International Journal of Disaster Risk Reduction, 34*, 1–10. https://doi.org/10.1016/j.ijdrr.2018.11.001

Hassler, U., & Kohler, N. (2014). Resilience in the built environment. *Building Research & Information, 42*(2), 119–129. https://doi.org/10.1080/09613218.2014.873593

Holmgren, D. (2009). *Future scenarios: How communities can adapt to peak oil and climate change*. Chelsea Green Publishing.

Mahtta, R., Fragkias, M., Güneralp, B., Mahendra, A., Reba, M., Wentz, E. A., & Seto, K. C. (2022). Urban land expansion: The role of population and economic growth for 300+ cities. *npj Urban Sustainability*, *2*(5). https://doi.org/10.1038/s42949-022-00048-y

UN News. (2023). *World must be ready to respond to next pandemic: WHO chief*. UN News. Retrieved 25 June, 2023, from https://news.un.org/en/story/2023/05/1136912

Part I
Innovations in Public Places

Chapter 2
Rethinking the Design of Vertical Green Spaces in the Post-pandemic Era: Visitor Behaviour and Real-Life Cognitive Experience at Crossrail Place, London

Ahmed Ehab and Tim Heath

Abstract The COVID-19 pandemic has profoundly impacted public spaces in cities worldwide, posing challenges in creating enjoyable, usable, and safe environments in high-density urban areas. Vertical urban spaces, such as roof gardens, have emerged as significant components of cityscapes, offering unique qualities in location, accessibility, and experience. This chapter investigates the Crossrail Place roof garden in Canary Wharf, London, through direct observation and 44 semi-structured interviews conducted before, during, and after the pandemic. The research explores critical aspects of vertical spaces, including accessibility, circulation, activities, design challenges, security, and safety. Findings highlight human behaviours, areas for improvement, design strategies, and the need for flexible regulation in these spaces. The chapter also examines the potential increased demand for vertical public spaces in the light of future pandemics and travel restrictions. This evidence is crucial for policy makers, urban designers, landscape architects, and government organisations to recognise the importance of vertical urban spaces in future city planning.

Keywords Roof garden · Vertical public realm · COVID-19 · Social resilience · London

A. Ehab (✉)
School of Design and Creative Arts, Loughborough University, Loughborough, Leicestershire LE11 3TU, UK
e-mail: a.abdelsalam@lboro.ac.uk

Human Factors Research Group, Faculty of Engineering, University of Nottingham, University Park, Nottingham NG7 2RD, UK

T. Heath
Department of Architecture and Built Environment, Faculty of Engineering, University of Nottingham, University Park, Nottingham NG7 2RD, UK

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_2

1 Introduction

The beginning of this century is characterised by a dramatic rise of urban populations and urban development globally. This 'urbanisation' has been more a movement of population to cities than just an arithmetical growth of population. Indeed, more than half of the world has been living in cities since 2007, according to the World Urbanisation Prospects 2014 of the United Nations (Desa, 2015). This equates to 54% of the world's population residing in urban areas and this is predicted to increase to 66% by 2050, meaning more than six billion people will live in cities. This growth is equivalent to around 1.4 million additional people each week (Leeson, 2018; Oldfield, 2019).

Lawson (2010, p. 292) in identifying the impact of this, states that: "The higher the density, the harder we have to work to design our cities in such a way that makes them pleasant and fulfilling places to live." Indeed, the main challenge of urban design today is to create a functional, sustainable urban space with the ability to accommodate and respond to diverse, intense, hybrid, dynamic, and unprecedented urban conditions (Cho et al., 2015; Pozoukidou & Chatziyiannaki, 2021). Eventually, the ways of understanding design and the utilisation of sustainable urban spaces requires both quantitative and qualitative reconceptualization. This requires a challenging of and reassessment of all previously existing and traditional notions of density, space, typology, and publicness, among others, in the context of high density, high-intensity urban environments. While conventional forms of public spaces and their timeless values remain immensely important, new ways of attaining and sustaining such values, as well as investigating possible new values and modes of publicness, in high-density conditions, are very crucial for a vibrant city (Cho et al., 2015; Lehmann, 2016).

A significant challenge in ensuring a safe environment during recent or future pandemics is spatial density. As the future of public space creation is contemplated, several questions arise, including the capacity of such spaces and the manner in which individuals co-occupy them (Megahed & Ghoneim, 2020). In 2020, even park benches were taped over to prevent groups of people from sitting on them. As COVID-19 restrictions eased in 2021, institutions ranging from intimate jazz clubs to expansive outdoor sports arenas, maintained infection-prevention measures, often more stringent than standard Fire Department regulations, with the risk of closure for noncompliance. In Spain, Italy, and France during 2020, residents creatively adapted apartment balconies to engage with others, fostering a collective "hive" of vertically arranged micro-spaces, where they maintained social distancing while sharing experiences (Gupta, 2020). This three-dimensional social interaction encompassed daily life, familial support, greetings, and cultural entertainment. Consequently, balcony spaces proved vital for mental well-being, transcending their utilitarian purpose (Peters & Halleran, 2021; Pouso et al., 2021). Reflecting on lockdown experiences, it becomes evident that public space design should not only prioritize enjoyment but also address acceptable density levels during hazardous times. Striking this balance

allows for pleasurable experiences while maintaining necessary social distancing measures.

Vertical green social spaces, predominantly privately owned and managed, are increasingly presented as 'public' spaces. These hybrid spaces represent an emerging typology of public space, exhibiting characteristics and regulations distinct from conventional models of public open spaces, such as public squares and parks (Childs, 2006; Hadi et al., 2018). Evolving hybrid urban spaces comprise elevated spaces and multi-level spaces, encompassing pedestrian bridges, roof gardens, sky courts, and sky parks (Cho et al., 2015; Oldfield, 2019). A considerable number of developers have neglected to acknowledge the potential of these spaces in augmenting amenities, well-being, productivity, social interaction, and revenue, often excluding them for cost-saving purposes (Lehmann, 2016; Pomeroy, 2013). Pomeroy (2013) further underscores that city governments can mandate such spaces as a condition of planning approval for major buildings, offering incentives like increased permitted height, supplementary parking spaces, and decreased property taxes. This approach is employed in Singapore, using a 'LUSH Index', a technique for quantifying the amount of green private and public space, as well as green façades provided by the developer (Timm et al., 2018).

Singapore has become a global exemplar in embracing the concept of vertical urbanism. The integration of sky-gardens and vertical social communal spaces is now an essential consideration in the development of new Singaporean high-rise buildings. Notably, sky-gardens pervade both Housing and Development Board (HDB) and private high-rise residential constructions (Oldfield, 2019; Pomeroy, 2012; Samant, 2019). The emergence of high-rise designs incorporating 'mixed-use' elements, such as shopping malls, residential units, workplaces, entertainment venues, and sky-gardens within a single edifice, is increasingly observed in numerous Western cities, including London and the United States (Al-Kodmany, 2018; Abdelsalam, 2018; Viñoly et al., 2015). These spaces have been well-established in many Asian cities throughout the majority of the twenty-first century. The expansion of public space offerings represents a marked shift from the conventional isolated high-rise structures, which are characterised by high-security, closed entrances, uniform single-purpose floors extending skyward, and a 'crown' discernible only from a distance (Li et al., 2022; Samant & Menon, 2018).

The phenomenon of vertical garden spaces has been rigorously examined and assessed by the authors through a variety of distinct programmes, encompassing recent endeavours in London. The research has focused on three diverse projects: Sky Garden (high-altitude, interior garden, situated at 20 Fenchurch Street), The Garden at 120 (mid-elevation, outdoor garden, also located on Fenchurch Street), and Crossrail Place (elevated yet low-rise, semi-indoor, semi-outdoor, based in Canary Wharf). The study has meticulously surveyed and analysed these initiatives with regard to the design and utilisation of vertical green communal spaces, as well as their ramifications on human behaviour, physical and psychological well-being prior to, during, and subsequent to the Covid lockdown.

The successes and failures of vertical garden spaces are reliant not only on the building design. They put responsibility on building owners and operators, to provide

a balance in how such spaces are governed; provide the necessary security for protection of the building users and residents; and retain benevolent intentions of allowing public freedom and more flexible rules to motivate social interaction (Hadi et al., 2018; Samant & Hsi-En, 2017). This emphasises the need for guidance and regulations on how sky-gardens and communal spaces are used and operated as places of community and social interaction. Questions do, however, remain about the hierarchical level of privacy, safety, over-bureaucratisation, and inclusiveness of the varied types of vertical public spaces arising from this mixed configuration (Cho et al., 2015; Oldfield, 2019).

1.1 Case Study: Crossrail Place

This chapter focuses on the analysis of the Crossrail Place roof garden in Canary Wharf, London. This project was chosen due to its unique nature in terms of location, accessibility, design, management, and activities. Crossrail Place roof garden is around 10,000 square metres of roofed and elevated park above the new underground route of the Elizabeth Line. The species of plants and their positioning in the 300m long park references the geography and history of Canary Wharf (Bosetti, et al., 2019). The Canary Wharf Group aimed to create a community park that could be used through all seasons of the year and the developers agreed with the local authority to build a public roof garden over the top of underground station, to compensate for the lack of green leisure opportunities in the London Docklands area (PLACE & WHARF, 2016) (Figs. 1 and 2).

The roof garden has direct access from the street level through a sequence of escalators and it also has two public elevators that take the visitors directly to the roof garden level. The roof garden is covered with a complex ETFE vaulted lattice timber roof that encourages daylight penetration and natural irrigation. Besides the green landscaping, there is a pub, restaurant, and an amphitheatre within the park. Crossrail Place is free to visit without pre-booking and it is open to the public from 09:00am to 09:00pm. The Crossrail Place roof garden is managed to the same rigorous standard as the rest of Canary Wharf estate. Indeed, the Canary Wharf security management plan was approved by the London Borough of Tower Hamlets to "prevent crime and fear of crime". The plan also states that there will be "no smoking and no consumption of alcohol" (except in the pub), and that the park will

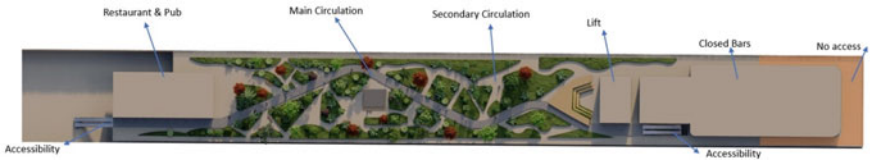


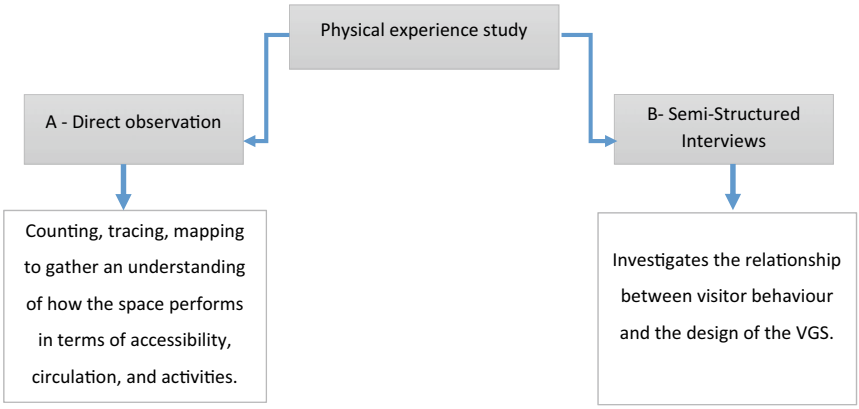
Fig. 1 Crossrail place roof garden layout, Canary Wharf, London. *Source* Author's Digital Model

Fig. 2 Crossrail place roof garden, Canary Wharf, London. *Source* Author

be "closed in the evening ". The original intention was to close the park at sunset, but the popularity of the pub and the restaurant have resulted in a change to now close at midnight. There is also "comprehensive CCTV coverage" and monitoring is undertaken from Canary Wharf's control room, with images "saved for a defined period" (Bosetti, et al., 2019).

2 Methodology

The purpose of this study was to explore how people are using vertical green social spaces before, during, and after the Covid19 pandemic. The specific objectives were to analyse the real-life cognitive experience of Crossrail Place visitors and to examine critical issues such as accessibility, circulation, activities, limitations of visitors, and social distancing. The method used in this study is a mixed approach as one tool on its own may not have provided all of the answers.



2.1 *Direct Observations*

The first method used in this study was direct observation at different times over a three-year period (2019–2022), inspired by and following Jan Gehl's method for studying public life (Gehl, 1989; Gehl & Svarre, 2013). Fieldwork of 'before, during, and after' was essential for data collection, to gather an understanding of how the space was experienced and how it then changed in terms of accessibility, circulation, and activities. This method required observation and data collection from 2019, before the pandemic, with many subsequent visits during the gradual relaxation of regulations, up to the present (2022). The author visited Crossrail Place many times to observe the layout and the users visiting the spaces (Table 1). All of the data collected was stored in a secure location in accordance with General Data Protection Regulation (GDPR) protocols.

2.2 *Semi-structured Interviews*

The study aimed to investigate the relationship between visitors' behaviour and the design of vertical social spaces. To achieve this, semi-structured interviews were conducted to explore the cognitive and physical experiences of space users and the impact on social interactions that occur and the factors that facilitate them. These interviews are embedded within a phenomenological qualitative approach that focuses on exploring the lived experiences of participants to understand the meaning and essence of a particular phenomenon (Cresswell, 1998; Peters & Halcomb, 2015). The phenomenological qualitative approach is particularly useful for delving into complex, multifaceted phenomena that are difficult to measure quantitatively. It

Table 1 Data collection date and time

Crossrail place roof garden, Canary Wharf, London		
Date	Time	Regulations
Thursday, 26/12/2019	12:00–15:00	Pre-pandemic
Friday, 27/12/2019	10:00–14:00	Pre-pandemic
Saturday, 11/07/2020	16:00–19:30	New rules with COVID 19
Sunday 18/10/2020	12:00–16:00	New rules with COVID 19
Saturday 22/05/2021	14:30–17:00	New rules with COVID 19
Sunday 23/05/2021	11:30–13:00	New rules with COVID 19
Thursday 11/11/2021	14:00–17:00	Post-pandemic
Friday 12/11/2021	12:00–15:00	Post-pandemic
Friday 31/12/2021	13:00–16:00	Post-pandemic
Saturday 03/07/2022	11:00–14:00	Post-pandemic

enables researchers to capture the richness, depth, and complexity of human experiences, as well as to uncover new insights and understandings that may not be apparent through other research methods (Loder, 2014; Rivera et al., 2021). This method circumvents the influences of pre-established theories that may lack such direct observational study analysis.

The fieldwork took place in Crossrail Place roof garden, Canary Wharf, London. Participants were the visitors to the space and they were interviewed during the site observation study. The semi-structured interviews were conducted with people from different age groups, however, all of the participants were aged 18 and over. The duration of each of the interviews was around 15 min. Forty-four interviews were conducted and analysed ($n = 44$) with the memos written in form of written notes, reflections, and the organisation of themes were formed throughout the analysis process.

3 Results

3.1 Direct Observation Study Results

The observational studies for the site analysis took place during weekends and weekdays to allow the direct and equal comparison with the four different conditions which are: 'pre-pandemic'; 'lockdown'; during 'pandemic'; and 'post-pandemic'. During official 'lockdown' the garden was totally closed, with no observation or data collection. The period of time referred to as 'pandemic' in this study is post-lockdown, when not everybody had been vaccinated, but limited degrees of relaxation for exercise, social meetings, and travel were permitted. 'Post-pandemic' is after the date that the government announced the relaxation of all regulations.

The pre-pandemic analysis shows that the average population during the hourly intervals did not exceed 45 visitors on weekends and 34 visitors on weekdays (Fig. 3). The roof garden's peak-time population was during the lunch break period between 12:00 and 14:30 pm. The average time visitors spent in the roof garden was about 30 min during weekends and 20 min during weekdays (Fig. 4). The analysis indicates that around 60% (n = 24) of the visitors spent about 10 min walking in the garden's primary circulation area and enjoying looking at the different plants. The field observations revealed that 82% of the visitors spent around 10–15 min sitting in the garden after their physical walk in the roof garden. The analysis indicated that around 43.5% (n = 17) of the people visiting the roof garden were adults (25–64 years), 30.5% (n = 12) were youths (15–24 years), 15.3% (n = 6) were children (00–14 years) and 12.8% (n = 5) were seniors (65 years and above).

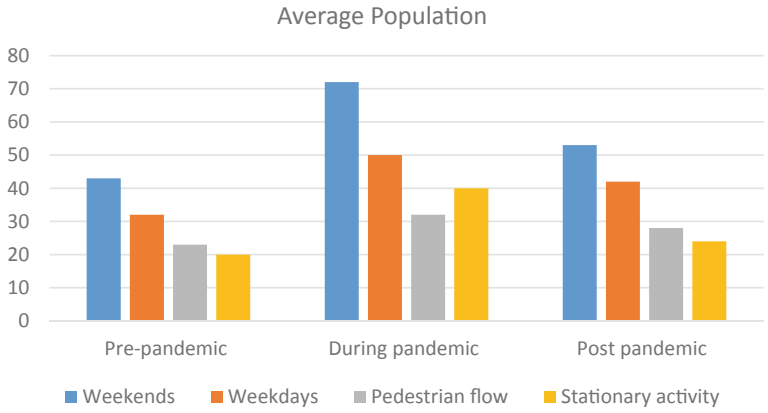


Fig. 3 Crossrail place roof garden visitor's average population. *Source* Author

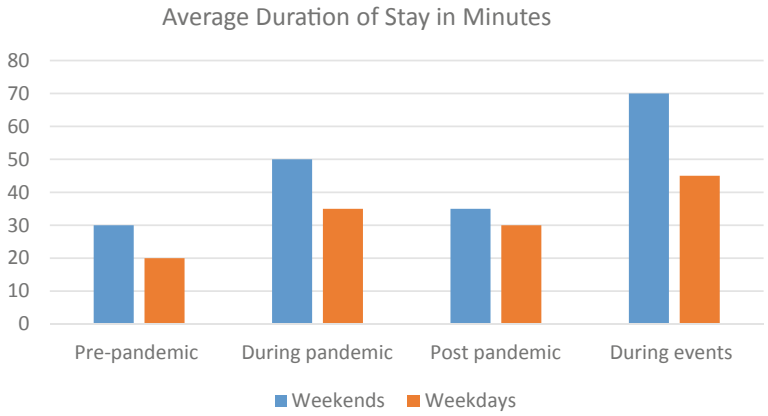


Fig. 4 Crossrail place roof garden visitor's average duration of stay in minutes. *Source* Author

The data collected during the pandemic period shows a significant increase in the number of people visiting the roof garden at one time. The average population per hour reached about 73 visitors on weekends and 50 visitors during weekdays (Fig. 3). Further analysis indicates that the pandemic had a significant impact on the sharp increase in the number of visitors and also on the duration of stays at the roof garden. The average time visitors spent on the roof garden increased to 50 min during weekends and 35 min during weekdays (Fig. 4). The results also revealed that there was also a massive increase in the number of youths and children visiting the roof garden during the pandemic. The analysis indicated that the number of youths (15–24 years) increased from 30.5% (n = 12) pre-pandemic to 40.65% (n = 25) during the pandemic. Moreover, there was an increase in the number of children visiting Crossrail Place from 15.3% (n = 6) to 18.5% (n = 11), especially during the weekend, when families were coming with their children (n = 15) for a picnics at the roof garden.

On the other hand, the data analysis after the pandemic period shows a significant decline in the average number of visitors to Crossrail Place compared with the data collected during the pandemic. The average population per hour reached 54 visitors on weekends and 43 visitors on weekdays (Fig. 3). The results indicate that the roof garden visitors' average population per hour decreased by 21% after the pandemic time, while it increased by 18.5% since the time before the pandemic. Moreover, the average time of stay in the roof garden has increased during the post-pandemic to reach 35 min during weekends and 30 min during the weekdays (Fig. 4). The observation study results highlighted the increase of adults visiting the roof garden on weekdays during the lunch break. The results show that the number of adults visiting the roof garden has increased compared to the pre-pandemic period to reach 20 visitors per hour during weekends and 23 visitors per hour during weekdays. The post-pandemic observation analysis also shows a slight increase in the average number of children from 6 (pre-pandemic) to 8 (post-pandemic) and youths from 12 (pre-pandemic) to 16 (post-pandemic).

The pre-pandemic observation study identified six different optional and social activities taking place in the roof garden. The main dominant activity taking place was walking, with visitors generally sauntering around the roof garden taking photos and looking at the plants. There were other people sitting with their friends on the wooden benches either having a conversation or eating and drinking. The results show that many of the people sitting and eating were workers from Canary Wharf, and that they preferred to have their lunch break in the roof garden. The amphitheatre was only used by a small number of people with a few families were sitting there. There was also a significant number of people passing through the roof garden to enter the bar or the restaurant. Although there was a vibrant movement in the roof garden there was a lack of social interaction with the only one being at the entrance of the roof garden where a public piano is located and some people were engaged either by listening to others or taking pictures (Figs. 5 and 6).

The data collected during the pandemic investigated the presence of new activities taking place in the roof garden such as reading, relaxing, and playing. Some of the participants spent their time in the roof garden by themselves, sitting on the wooden

Fig. 5 Crossrail place roof garden visitor's activities pre-pandemic. *Source* Author

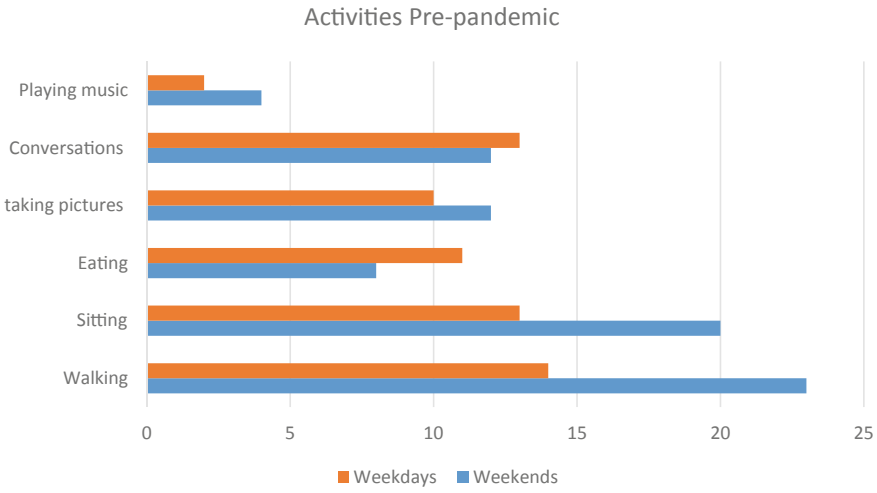


Fig. 6 Bar graph for the average number of visitor's activities pre-pandemic. *Source* Author

benches near the plants, relaxing and reading their books. There were also short story stations with touch-free sensors newly placed in the roof garden to motivate people to read. The number of people sitting in the roof garden notably increased since the pre-pandemic period. There were more families and children coming to the roof garden for a picnic on the weekends. Also, children were playing and running in the roof garden and there was a new jumping game placed near the entrance of the garden. The roof garden visitors living in Canary Wharf were coming to Crossrail Place to meet their friends and they described the roof garden as "a safe place to meet friends and hang out in a green environment". This was further discussed during the semi-structured interviews (Figs. 7 and 8).

The data analysed from the post-pandemic period indicates that the roof garden activities and use have changed to become more active than during the pre-pandemic

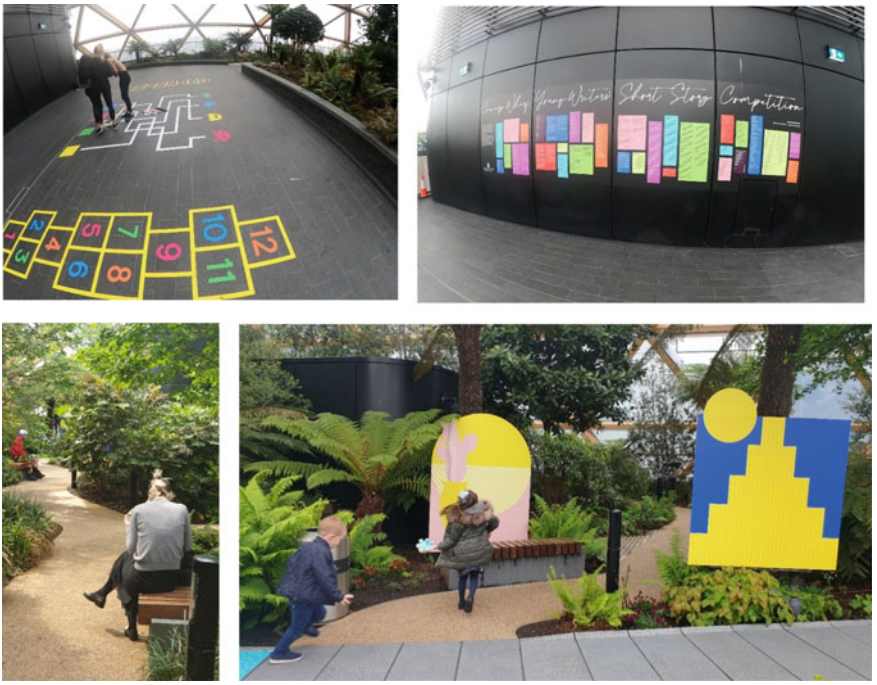


Fig. 7 Crossrail place roof garden visitor's activities during the pandemic. *Source* Author

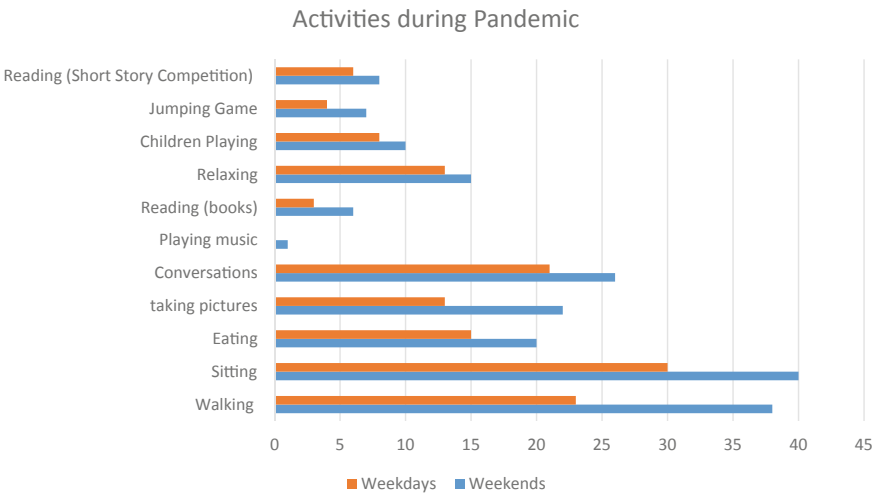


Fig. 8 Bar graph for the average number of visitor's activities during pandemic. *Source* Author

period. The short story stations have become more popular and are now ongoing attractions where the visitor can choose the length of the story, one, three or five minutes, and the dispenser will select a mystery story for them to read during their visit. The amphitheatre has also been open for performances and music events during the summer of 2022. The roof garden delivers a free ticket programme of festivals, performances, and music at the amphitheatre, which is known as "Bloom". During these summer events, the roof garden reached its highest number of users, although during the normal weekday the space seems to be less active and vibrant compared with the pandemic period (Figs. 9 and 10).

Fig. 9 Crossrail Place roof garden visitor's activities post-pandemic. *Source* Author

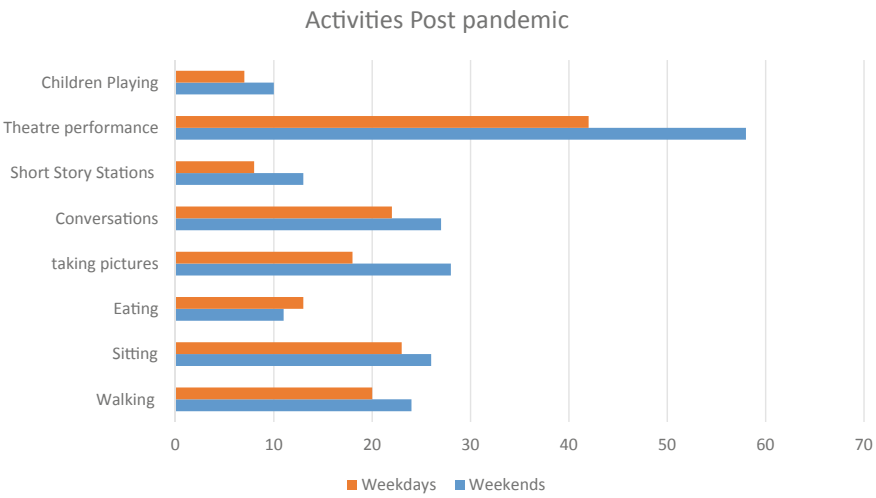


Fig. 10 Bar graph for the average number of visitor's activities post pandemic. *Source* Author

3.2 Interview Results

A total of 44 interviews were completed; 43.2% (19) were male and 56.8% (25) were female. The average age of participants was 30.3 years. Around 61.4% (27) of the interviewees were living or working in Canary Wharf, 25% (11) were living in London and, 13.6% (6) were tourists and just visiting London for a short time. The interview analysis focused on five overarching themes: the purpose of the visit; accessibility; design concerns; suggested design features and activities; and visiting experience.

3.2.1 The Choice and the Purpose of the Visit

The most common reasons for visiting Crossrail Place identified by visitors were: 'for resting and meditation'; 'meeting a friend'; 'lunch break'; 'family picnic'; and that 'it's free to visit'. A significant number of participants liked the fact that the roof garden theme is frequently changing, encouraging them to re-visit the roof garden. Many participants stated that they are regular visitors to the roof garden, as they live or work within a short distance of Crossrail Place and some participants, working in Canary Wharf, take regular lunch breaks in the roof garden. Some other participants first knew about the roof garden from social media posts.

The majority of the participants stated that they would stay no more than one hour in the roof garden. 68% of the participants (n = 30) had previously been to Crossrail Place. 36% of the participants were regular visitors to the roof garden and visit the garden on a weekly basis, while 45% (n = 20) visit the roof garden monthly.

3.2.2 Accessibility

When asked about the accessibility to the roof garden, participants most commonly mentioned that it is accessible from the ground level through escalators but that it's not easy to find from the street level. Most of the participants who visited the roof garden for the first time stated that they dislike the lack of visual access and connection from the street level to the roof garden (Fig. 11). First-time visitors also mentioned that they had to follow the posted signs or Google Maps to find their way up to the roof garden. Participants did, however, frequently mention that access to the roof garden is helped by the proximity to public transportation such as the newly opened Elizabeth Line, the Jubilee underground line, and the nearby bus stops. Analysis of the interviews also identified that most of the participants described the garden as an accessible place for people with special needs and wheelchairs, although there were some complaints about the lift positioning and the visual access of these to the surroundings.

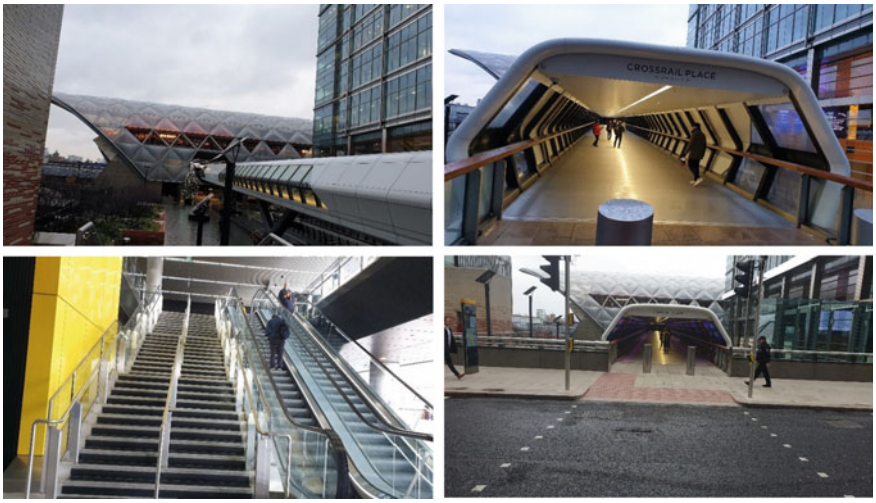


Fig. 11 The Crossrail Place roof garden accessibility from the street level. *Source* Author

> It wasn't that clear from the ground level. The accessibility was a bit confusing. If you don't know the place, you might need to use Google maps, so I would say you have to search for it a bit (Male, aged 30 years, living in London).

3.2.3 Circulation

Participants had mixed responses when asked about the roof garden's circulation. The most commonly mentioned response was that the curved pathways encourage the visitors to move around the roof garden and they give it a sense of enclosure and enable people to bond with the natural environment (Fig. 12). Others mentioned that it's important for walking paths to be attractive, non-uniform, and to encompass shade and natural features. The garden's curved paths could, however, be confusing for first-time visitors. Participants commonly mentioned that the curved pathways are narrow for people to walk if there are people sitting alongside the paths. People sitting on the fixed benches also mentioned that they need more privacy as they felt their personal space was being encroached upon by people squeezing past as they walked around.

> I like the circulation and the curved paths make it feel more like a garden (Female, aged 24 years, living in London).

> I think the circulation is good because it gives you a place to sit as well near the plants, although the walkways are a bit narrow (Female, aged 28 years, living in Canary Wharf).

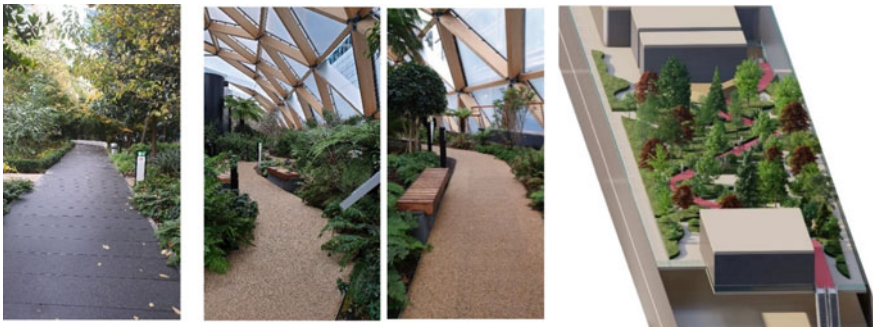


Fig. 12 The Crossrail Place roof garden circulation. *Source* Author

3.2.4 Safety—COVID

The majority of participants (n = 40) described Crossrail Place as a safe place to visit during the COVID-19 pandemic. Participants also liked the fact that the roof garden is well-ventilated and open, making them feel safe compared to other roof gardens in London (Fig. 13). Numerous participants (n = 18) also stated that visiting the roof garden during the pandemic had a positive impact on their mental well-being. A significant number of participants (n = 24) stated that they would get dismayed when the roof garden was closed, and commonly mentioned that the roof garden should be open, even during a pandemic. A significant number of participants also mentioned (n = 35) that they felt the need for more open-air and well-ventilated roof gardens in London. Participants frequently suggested that roof gardens have a positive future in London, but they need to be well-integrated and managed by local authorities, not only the private institutions that manage the estate which includes the vertical garden spaces.

> …more of these spaces within the pandemic would be better. It's better than a public park where everyone can just walk in; but here definitely, they can manage and control the number of people visiting the roof garden and set some rules to make sure everyone is safe (Female, aged 28, living in Canary Wharf).

> …having spaces like this is something positive to the physical and mental wellbeing during the pandemic, as it's private; people might want to get alone in a green space and feel safe (Male, aged 35, working in Canary Wharf).

> Being in a green space is nice, it reminds me of not being in a city. …public roof gardens especially in metropolitan cities are essential. … they have a positive future …they contribute to the mental wellbeing of all those who use it (Male, aged 26, tourist from Spain).

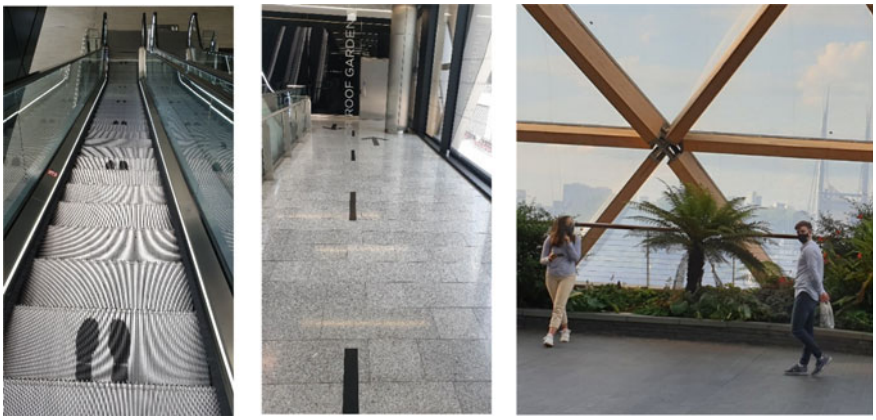


Fig. 13 The Crossrail Place roof garden safety and social distancing rules during the COVID 19 pandemic. *Source* Author

3.2.5 Territorial Rights

Visitors were asked to discuss the real level of territorial rights for the public in the roof garden compared to a genuinely public park or public footpath with long-established rights of access. London and other British cities are full of apparently public spaces which are, in reality, privately managed estates, such as the whole Canary Wharf district, and the 'Freeports'—in which the 'right to roam' is very tightly restricted. Hospitals, campuses, transport, business parks, and shopping malls are a few examples of publicly accessible spaces which are, in law, private estates.

Most participants (n = 35) appreciated the fact that the roof garden is safer than most of London's public parks due to the high level of security. Significantly, 41% of the respondents (n = 18) stated that they are unaware of roof garden rules and restrictions and of the legal distinction of the roof garden as a truly public or private space. This could imply that the management has been successful in avoiding obtrusive signs and noticeboards.

Other participants (n = 10) recognised the garden as a private space and raised the issue that they cannot do some activities they are used to being able to do in public parks (Fig. 14). A significant number (n = 10) understood the roof garden as a quiet green place to rest and relax but they accepted restrictions on freedom to do activities such as walking dogs, picnicking, sleeping, photography, cycling, ballgames, busking, lighting fires, skateboarding, and playing loud music.

> It's more private and it gives you a sense of security. I mean it's more secure, there are restaurants and people walking around; even if you come at night, it's fine but then compared to a park … a public park might be a bit scary, especially during late evening time (Female, aged 25, living in Canary Wharf).

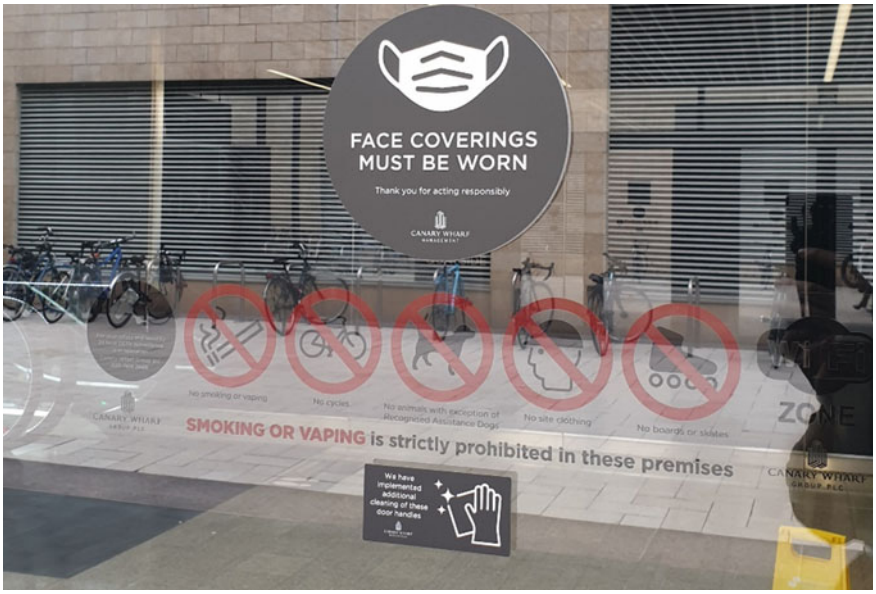


Fig. 14 The Crossrail Place roof garden list of rules and restrictions. *Source* Author

> I cannot do the same activities if I compared this with a public park like Hyde Park. We cannot go for a picnic here, sit in the grass with our dog and listen to music (Female, aged 28, living in Canary Wharf).
>
> I know that it's private property and I would say that most people don't know that this is private property. I am aware of things; like actually you can be accosted by the security guards for taking photos. You can still take them, but you have to be careful as most people don't know that this is private property and it has its own security rules. I don't think there is any reason though that anybody would feel particularly constrained (Female, aged 66, living in London).

3.2.6 Activities

Participants primarily reported using the roof garden for walking, socialising, eating and drinking, taking photos, and enjoying the green environment. Indeed, "*relaxing in a safe and green environment*" was the preferred roof garden-based activity for most participants. The majority of the participants living or working in Canary Wharf highly valued the roof garden as a place for eating and relaxing during their break times. The participants, living or working in Canary Wharf, also highlighted that the roof garden benefits from being centrally located in a place enriched by restaurants, cafes, and pubs. Most of the families stated that a roof garden is a safe place for their children to play and run around. Some of the participants ($n = 12$) also mentioned that they would like to see more vibrant activities in the roof garden. The author's

photographs (see Fig. 5) show an example of a display of colourful artwork, as a way of varying the user experience, compared with their experiences from previous visits.

3.2.7 Suggested Activities and Design Features

When describing what they would change to improve the roof garden design, the most frequently mentioned comments were: more comfortable and movable seating spaces; a sheltered area to protect from rain; a water fountain; varied widths of pathways; and more flowers and plants. Others mentioned such features as an outdoor café, kids playing area, pet-friendly zone, interactive night lighting, and an outdoor viewing platform to see Canary Wharf. Most of the participants (36 respondents; 81% of those interviewed) stated that a water feature and a covered roof area to protect visitors from rain during the winter was highly needed to improve the design. A significant percentage of the older adult participants (8 respondents; 18% of the interview sample), however, stated that they are satisfied with the current design of the roof garden and they don't think the roof garden needs other activities or new design elements.

Participants had mixed responses when asked about what would encourage them to interact with others or what they would change to help facilitate social interaction. The most commonly mentioned responses included organised events such as a magical installation inspired by the Jardin Majorelle in Marrakech, and live music events at the amphitheatre, either for free listening (licensed buskers), or for an advertised event with tickets. Many participants also stated that some of the seating benches should be replaced with interactive social seating areas. Some participants also spoke about educational and interactive features such as banners describing the plants, statues, public art on the roof garden walls, a piano, games tables, and a Koi pond. There was a public piano, pre-covid, which the frequent visitors remembered, however, this was removed because of the labour of sanitizing it after each use and it has not been replaced despite their no longer being a requirement for sanitisation.

The most frequently mentioned features regarding what would encourage participants to be active in the roof garden included more plants and flowers, fitness equipment, yoga classes, table tennis tables, interactive night lighting pathways, and different themes and events. Walking was the most dominant activity by all the age groups and many participants stated that they feel safe allowing their children to run and play freely in Crossrail Place area. Features that participants (26 respondents; 59% of the interview sample) suggested being added to the roof garden were sporting equipment, wider walking pathways, organised events and a kid's playing area.

> *…some tables and chairs where you could actually sit with someone opposite them, more social spaces as it doesn't feel super-social. Some spaces where you can actually sit with more people instead of just benches that make you feel more isolated (Female, aged 26, living in Canary Wharf).*

…maybe more things you can interact with like reading spaces. Like you see this statue over there … you can read about it. …more things like that will be pretty cool (Female, aged 25, living in London).

They can do more educational and interactive stuff. There were a few banners describing what plants are here and the different species…it's free space so obviously they would not put too much money into something for which no one paying to get in … they could do a few more educational things (Male, aged 29, living in Canary Wharf).

If they have a fishing pond that would be quite lovely, it goes with the overall design and environment (Female, aged 27, living in London).

Sports may be like a calisthenics park. I would like to exercise here (Male, aged 31, living in Canary Wharf).

4 Discussion

This research study has highlighted the outcomes of the observation results and the semi-structured interviews conducted at Crossrail Place before, during, and after the COVID pandemic and a summary of the core findings is presented below.

This study has identified an increase in both the number of people visiting Crossrail Place during the pandemic and the average time visitors spent there. This increase in the number of youths, children, and families visiting the roof garden reveals the sense of safety and security in the place. Overall, a majority of the participants (90%) found the roof garden to be a safe place to visit during the COVID-19 pandemic due to the roof ventilation and the high-security. The study also highlighted the presence of new activities taking place in the roof garden during the pandemic such as reading (short story stations), relaxing, playing, and family picnics. A significant percentage of the participants (41%) reported that visiting the roof garden on regular basis during the pandemic to sit, relax, and chat with friends had a positive impact on their mental well-being.

The results of this study align with previous studies which discussed the design problems and principles that need to be considered when designing vertical urban spaces (Oldfield, 2019; Cho et al., 2015; Pomeroy, 2013). In the Crossrail Place case study, many design aspects need to be improved in accessibility, circulation, design, and management. These include improvements to the visual accessibility to the roof garden from the street level, and widening the narrow pathways that cause a feeling of a lack of privacy. There is also an essential need for a sheltered canopy to protect the people from the rain in the open sections, a need for public toilets on the roof garden floor, an outdoor viewing platform, and comfortable and movable seating chairs instead of fixed wooden benches.

Nine key qualities that the study participants most frequently refer to when describing their ideal roof garden were: accessibility; provision of activities, comfort; sociability; quality of management; publicness; security; green natural planting; and natural ventilation. Other principles that must be considered when designing an

accessible roof garden include: a variety of transportation options in the wider urban context; a direct connection between the roof garden and the street-level surroundings; and a semiotic indication, signalling that there is a pleasing roof garden interior to be found if visitors come into the building (e.g. green tree foliage in a sky garden visible to a person walking at street level near the building communicates more effectively than signs) (Samant, 2019; Viñoly et al., 2015; Yeang, 2002). The roof garden, once discovered, must also function for people with special needs. In short, visitors must have easy access and feel that they can walk comfortably in the roof garden.

Seating organization is one method to facilitate social activity in vertical green spaces and a variety of seating types is therefore advisable. The main challenge with seating fixtures in roof gardens is not the lack of provision, but instead, the arrangement and positioning of seating, grouping, design, the level of flexibility, and availability of weather protection. Key aspects of quality seating in roof gardens therefore include flexibility and adjustability, together with comfort, and arrangement (Cho et al., 2015; Nordh & Østby, 2013). Indeed, movable chairs and benches with different orientations can improve the variety and choice of seating, for comfort and user experience. When implemented well, good seating improves social interaction and passive activities, such as people watching others. Interactive objects of interest such as fountains, plants, installations, game facilities, interactive displays, pianos, swings, and public art sculptures are also highly recommended to activate a public roof garden. These elements bring a unique character to the roof garden while also serving as an attraction that encourages visitors to stay longer, or return later with friends (Rivera et al, 2021).

Vertical urban space management in vertical roof garden spaces should encourage inclusion through light-touch regulations, rather than the hard exclusion of undesirable behaviours through restrictions on people, activities, and animals unless their risk assessment is aware of realistic nuisances and threats (Hadi et al., 2018; Oldfield, 2019; Samant & Hsi-En, 2017). Indeed, there is a need for creative thought to actions and considerations that activate life in the vertical public realm rather than prohibit them. New guidelines should therefore limit the number of restrictions to essential and reasonable ones, employ plans for user participation in the roof garden management, and regulate spatial uses and actions, rather than just prohibiting them. These actions can be regulated by offering safe spaces for animals and smokers and those playing with balls and skateboarding.

It is also opportune for designers to consider the potential of new technologies to better engage the public in the design process. Indeed, previous research suggests that the principles of intelligent design for these vertical social spaces should be used with the flexibility derived from a deeper understanding of justifications and interrelations. Computer modelling technology such as ‘Virtual Reality’ (VR) can help as a method to form a new experience of ‘Extended Reality’ (XR) thereby acting as a design tool that engages human users as active participants in the design process (Stals & Caldas, 2022; Ehab & Heath, 2023; Van Leeuwen et al., 2018). The use of XR in the design of vertical social spaces can enable a strategic intervention approach that identifies specific opportunities, selecting a set of improvements, avoiding mistakes, and prioritising the design actions that enhance the quality of the vertical urban

space (Ehab et al., 2023; Bussell et al., 2023). These new design actions could be tested and changed by the users in their real-time in their 'virtual world' and therefore inform design decisions. This can all be done before the 'real world' physical roof garden or refurbished roof space has been built and therefore improve on the design outcome and future user experience.

5 Conclusions

This study has provided evidence that during the COVID-19 pandemic the number of visitors to Crossrail Place roof garden increased. Significantly, 79% of the study participants (n = 35) declared that London needs more open and well-ventilated roof gardens that should be part of the city's future development plan. This chapter gives an overview of the future design principles and limitations for the design of vertical green spaces in the post-pandemic era. Most of the interviews were conducted by strolling through the garden with the interviewees, a method which helped in analysing context-specific information by observing their behaviour and reactions, and not merely hearing their words. This enabled the researcher to identify how social and physical factors interact to expose the characteristics that influence the use of Crossrail Place.

This research study on the current design and management of Crossrail Place has identified critical issues regarding the design of vertical roof garden spaces as well as how these ca change during pandemic situation. These include factors such as accessibility, circulation, activities, suggested design features, limitations of visitors, and social distancing. The study's results have important implications for the future design and need for vertical social spaces and roof gardens in London. It must always be said that further investigation is needed and that this has been amongst the first studies that explore how people are using vertical green social spaces before, during, and after the Covid19 pandemic. There will be more requirements and opportunities for the study of vertical social spaces as their implementation as new public spaces in cities spreads, especially if other cities are inspired by outstanding exemplars such as Singapore.

Disclosure Statement The authors have no financial interest to declare.

Funding The work was supported by the Faculty of Engineering University of Nottingham Research Excellence Ph.D. Scholarship.

References

Abdelsalam, A. E. (2018). Sustainable vertical urbanism as a design approach to change the future of hyper density cities. *Journal of Advance Research in Mechanical & Civil Engineering, 5*(7), 2208–2379.

Al-Kodmany, K. (2018). Sustainability and the 21st century vertical city: A review of design approaches of tall buildings. *Buildings, 8*(8), 102.

Bosetti, N., Brown, R., Belcher, E., & Washington-Ihieme, M. (2019). *Public London: The regulation, management and use of public spaces.* Published by Centre for London.

Bussell, C., Ehab, A., Hartle-Ryan, D., & Kapsalis, T. (2023). Generative AI for immersive experiences: Integrating text-to-image models in VR-mediated co-design workflows. In C. Stephanidis, M. Antona, S. Ntoa & G. Salvendy (Eds.), *HCI International 2023 Posters. HCII 2023. Communications in computer and information science* (Vol. 1836). Springer. https://doi.org/10.1007/978-3-031-36004-6_52

Childs, M. C. (2006). *Squares: A public place design guide for urbanists.* University of New Mexico Press.

Cho, I. S., Heng, C.-K., & Trivic, Z. (2015). *Re-Framing urban space: Urban design for emerging hybrid and high-density conditions* (1st ed.). Routledge. https://doi.org/10.4324/9781315725147

Cresswell, J. W. (1998). Qualitative inquiry and research design: Choosing among five traditions.

Desa, U. N. (2015). *World urbanization prospects: The 2014 revision* (p. 41). United Nations Department of Economics and Social Affairs, Population Division.

Ehab, A., & Heath, T. (2023). Exploring immersive co-design: Comparing human interaction in real and virtual elevated urban spaces in London. *Sustainability, 15*(12), 9184.

Ehab, A., Burnett, G., & Heath, T. (2023). Enhancing public engagement in architectural design: A comparative analysis of advanced virtual reality approaches in building information modeling and gamification techniques. *Buildings, 13*(5), 1262.

Galletta, A. (2013). Mastering the semi-structured interview and beyond: From research design to analysis and publication (Vol. 18). NYU Press.

Gehl, J. (1989). A changing street life in a changing society. *Places*, *6*(1).

Gehl, J., & Svarre, B. (2013). Counting, mapping, tracking and other tools. In *How to study public life*. Island Press. https://doi.org/10.5822/978-1-61091-525-0_3

Gupta, N. (2020). <? covid19?> singing away the social distancing blues: Art therapy in a time of coronavirus. *Journal of Humanistic Psychology, 60*(5), 593–603.

Hadi, Y., Heath, T., & Oldfield, P. (2018). Gardens in the sky: Emotional experiences in the communal spaces at height in the Pinnacle@ Duxton, Singapore. *Emotion, Space and Society, 28*, 104–113.

Lawson, B. (2010). The social and psychological issues of high-density city space. In *Designing high-density cities* (pp. 309–316). Routledge.

Leeson, G. W. (2018). The growth, ageing and urbanisation of our world. *Journal of Population Ageing, 11*, 107–115.

Lehmann, S. (2016). Sustainable urbanism: Towards a framework for quality and optimal density? *Future Cities and Environment, 2*, 1–13.

Loder, A. (2014). 'There's a meadow outside my workplace': A phenomenological exploration of aesthetics and green roofs in Chicago and Toronto. *Landscape and Urban Planning, 126*, 94–106.

Li, Y., Du, H., & Sezer, C. (2022). Sky gardens, public spaces and urban sustainability in dense cities: Shenzhen. *Hong Kong and Singapore. Sustainability, 14*(16), 9824.

Megahed, N. A., & Ghoneim, E. M. (2020). Antivirus-built environment: Lessons learned from Covid-19 pandemic. *Sustainable Cities and Society, 61*, 102350.

Nordh, H., & Østby, K. (2013). Pocket parks for people–a study of park design and use. *Urban Forestry & Urban Greening, 12*(1), 12–17.

Oldfield, P. (2019). *The sustainable tall building: A design primer*. Routledge.

Peters, T., & Halleran, A. (2021). How our homes impact our health: Using a COVID-19 informed approach to examine urban apartment housing. *Archnet-IJAR: International Journal of Architectural Research, 15*(1), 10–27.

Peters, K., & Halcomb, E. (2015). Interviews in qualitative research. *Nurse Researcher* (2014+), *22*(4), 6.

Place, C., & Wharf, C. (2016). Current practice. Timber gridshells: Architecture, structure and craft, 219.

Pomeroy, J. (2012). Room at the top—the roof as an alternative habitable/social space in the Singapore context. *Journal of Urban Design, 17*(3), 413–424.

Pomeroy, J. (2013). *The Skycourt and Skygarden: Greening the urban habitat*. Routledge.

Pouso, S., Borja, Á., Fleming, L. E., Gómez-Baggethun, E., White, M. P., & Uyarra, M. C. (2021). Contact with blue-green spaces during the COVID-19 pandemic lockdown beneficial for mental health. *Science of the Total Environment, 756*, 143984.

Pozoukidou, G., & Chatziyiannaki, Z. (2021). 15-minute city: Decomposing the new urban planning eutopia. *Sustainability, 13*(2), 928.

Rivera, E., Timperio, A., Loh, V. H., Deforche, B., & Veitch, J. (2021). Critical factors influencing adolescents' active and social park use: A qualitative study using walk-along interviews. *Urban Forestry & Urban Greening, 58*, 126948.

Samant, S., & Hsi-En, N. (2017). A tale of two Singapore sky gardens. *CTBUH Journal, 3*, 26–31.

Samant, S., & Menon, S. (2018). Exploring new paradigms in high-density vertical hybrids high-rise buildings exploring new paradigms in high-density vertical hybrids. *International Journal High-Rise Build, 7*(2), 111–125.

Samant, S. (2019). Cities in the Sky: Elevating Singapore's urban spaces. *International Journal of High-Rise Buildings, 8*(2), 137–154.

Stals, A., & Caldas, L. (2022). State of XR research in architecture with focus on professional practice–a systematic literature review. *Architectural Science Review, 65*(2), 138–146.

Timm, S., Dearborn, L., & Pomeroy, J. (2018). Nature and the city: Measuring the attention restoration benefits of Singapore's urban vertical greenery. *Technology| Architecture+ Design*, *2*(2), 240–249.

Van Leeuwen, J. P., Hermans, K., Jylhä, A., Quanjer, A. J., & Nijman, H. (2018, November). Effectiveness of virtual reality in participatory urban planning: A case study. In *Proceedings of the 4th Media Architecture Biennale Conference* (pp. 128–136).

Viñoly, R., Blomberg, C., & Blanes, M. (2015). Challenges and benefits of integrating public space into tall buildings. *CTBUH Research Paper*, 282–287.

Yeang, K. (2002). *Reinventing the skyscraper: A vertical theory of urban design.* Academy Press.

Chapter 3
New Green Spaces for Urban Areas: A Resilient Opportunity for Urban Health

Lorenzo Diana, Francesco Sommese, Gigliola Ausiello, and Francesco Polverino

Abstract The Covid-19 pandemic underlined the positive role of public green spaces for the physical and mental health of citizens forced into long periods of immobility and social distancing. In cities with high population density, these restrictions have underlined the need to increase public green spaces and their accessibility. Indeed, green spaces have the role of improving urban health in terms of mitigating environmental impact, improving air quality, reducing the transmission of diseases, and promoting the psycho-physical well-being of citizens. After analysing the possible Nature-Based Solutions (NBSs) applicable at urban scale and their advantages in terms of urban health, this chapter aims to apply them to public spaces (such as streets and squares) and large public buildings located in the central areas of historic high-density cities. The use of NBSs in the transformation and regeneration of consolidated urban fabrics aims at enhancing their resilience, constituting new public spaces with social purpose, useful even in emergency periods of physical distancing. A new methodological approach is implemented and applied in the compact fabric of the historic city centre of Naples, through two phases: (i) as built analysis, (ii) intervention. Several buildings and public spaces are identified and the readiness to increase accessible and non-accessible green spaces is assessed, to obtain spaces for social use, as well as to mitigate the environmental impact. Pre- and post-intervention results show that non-accessible green spaces are easier to increase through the construction of green roofs, while accessible green spaces that can be used by citizens are more complex. Nevertheless, a significant increase in accessible green spaces is achieved. The application of NBSs in urban areas, is not only a technical strategy, but also a resilient solution, as it can transform some existing spaces into green ones with social value, and improve urban health.

Keywords Green spaces · Nature Based Solutions · Urban health · Urban resilience · Pandemic emergency

L. Diana (✉) · F. Sommese · G. Ausiello · F. Polverino
Department of Civil, Building, and Environmental Engineering (DICEA), University of Naples Federico II, Naples, Italy
e-mail: lorenzo.diana@unina.it

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_3

1 Introduction

The concentration of a relevant rate of the world population in urban areas (up to 70% by 2050 according to World Health Organization) forces adaptation systems and regenerative strategies for healthy and liveable cities. The scarcity of green spaces, along with the urban heat island phenomenon and the general pollution of urban areas, contributes to drastically limiting the overall sense of urban health. Whilst international governments in the last few years have been committed to reducing polluting emissions through the development of protocols and directives, little interest has yet been paid to the issue of urban health, resulting even more evident during the COVID-19 pandemic. The pandemic strongly affected urban contexts both directly—showing higher rates of infection recorded in urban contexts (Barbarossa, 2020; Johns Hopkins University, n.d.)—and indirectly—strongly entailing social effects due to distancing and limitation in visiting accessible green spaces.

Current urban regeneration strategies, tending towards a holistic manner to improve urban decayed contexts according to different (social, environmental, and economic) aspects (Musco, 2009), pay specific attention to climate change adaptation strategies, especially given the growing number of extreme events affecting urban contexts in recent years. Among the various adaptation strategies, Nature-Based Solutions (NBSs) foster the integration of natural green spaces into land management, thus coupling the preservation of the urban environment and the socioeconomic development of cities, triggering urban health and urban resilience (Frantzeskaki, 2019; Sommese & Diana, 2022). The combination of environmental, resilience, and health goals is achieved through the creation of healthier and more liveable spaces by ensuring the creation of green spaces that can be walked on comfortably by the population even in highly urbanised contexts, and through greater soil permeability. It must be underlined how the environmental benefits resulting from the application of greening strategies have been extensively studied in the literature over the last decades, while little has been said about the health benefits for inhabitants. Due to the lack of extensive green public spaces, the application of NBSs is particularly interesting in regeneration interventions on central areas of historic cities. The simple reconversion of courtyards and cloisters of historic public buildings, for example, and their inclusion into urban itineraries would increase the outdoor walkable public space with positive consequences on the health of citizens.

1.1 The Role of Urban Green Spaces During Pandemic Emergency

Coronavirus impacted strongly on European cities and common people's lives, determining direct and indirect consequences for human wellness. Directly, a huge number of patients with contagious Covid-19 diseases blocked up hospitals, emergency departments, and intensive care units. Such congestion shows that health systems,

especially in Italy, are not resilient and even standard disease surveillance and prevention has been reduced. This reduction is mainly due to the March–May lockdown of 2020. During this period, clinics were considered unnecessary healthcare structures providing activities that could be postponed and for such a reason they were temporarily closed (Osservatorio Nazionale Screening, 2020).

The experience of the Covid-19 pandemic impacted even indirectly, showing how important, especially in the period of mobility restrictions, the role of natural green spaces is for physical and mental health (Lopez, 2020). Social isolation made the population more vulnerable to the risk of anxiety, depression, and loneliness, especially the elders who were the most encouraged to maintain social distances. Nevertheless, despite these negative drivers, the pandemic experience has directed citizens towards mobility patterns and recreational spaces other than their usual ones (Korpilo et al., 2021). Green spaces have become refuge places for citizens forced into isolation and social distancing, with detrimental consequences for their well-being, especially when living in high populated urban areas with a shortage of public spaces (Samuelsson et al., 2020).

Due to their ability to reduce stress and provide physical and mental relaxation, green spaces, such as parks and gardens, and spaces for pedestrian mobility have been favoured, becoming an alternative to grey and enclosed spaces for motor and recreational activities (Fong et al., 2018). It's necessary to underline that the social distancing measures imposed by various world governments varied according to the severity of the pandemic emergency. In Italy, for example, restrictive measures allowed sports activities and outdoor walks only close to homes (Ugolini et al., 2020). Despite that, several recent studies, presented in the literature, have underlined the advantage of urban green spaces. The study proposed by (Venter et al., 2020) demonstrates the increase in pedestrian mobility in city parks and peri-urban forests of Oslo. (Ugolini et al., 2020) proposed an online survey in six European countries on changes in citizens' habits related to visiting green spaces, showing that green parks and urban gardens were the most visited places during the pandemic. (Lu et al., 2021) showed that the propensity to visit green spaces in Asian regions increased significantly during pandemic periods due to the physical and mental benefits, including maintaining physical activity, reducing the use of electronic devices, reducing stress, and avoiding household stressors. Therefore, green spaces are also able to promote social cohesion, as it is possible to maintain social contact while respecting imposed distancing measures.

1.2 Urban Resilience

Urban areas characterised by dense and compact fabrics are often not equipped with large green spaces, so different strategies are required to create resilient urban systems depending on the intervention scenario. (Meerow et al., 2016) define urban resilience as "*the ability of an urban system–and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales—to maintain or*

rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity". Adaptation strategies deal with possible disruptive events (climate change, food shortage, energy stress), including potential epidemic scenarios whose likelihood has constantly increased over the past decades (Madhav et al., 2017). The urban resilience perspective allows (Meerow et al., 2016) to emphasise the role of proactive planning in the management of emergency events, the redevelopment of buildings and urban areas, the increase of green spaces (floors, roofs, facades) in existing urban fabrics.

Clear planning of urban resilience strategies through greening measures requires long-term actions involving multiple actors at different scales. Indeed, greening planning is effective from social, economic, and ecological perspectives (Grădinaru & Hersperger, 2018). The involvement of citizens is also evident from the multiplying of initiatives by private individuals such as "*adoption of public green*" (Sturiale & Scuderi, 2019). Linking with regional green systems is also crucial for the development of urban green spaces (Hersperger et al., 2019). Investment in urban green spaces should concern both proactive measures for urban resilience, public and social health, and ecological opportunities to balance the human-nature relationship as a protection against future pandemics (Geary et al., 2021).

1.3 Aims and Scope

While cities are the main places where a greater number of infections occurred due to larger social relations and activities, they are also the most favourable places where it is possible to outline and test solutions to increase green spaces aimed at encouraging outdoor social activities. Thus, the increasing use of green spaces makes it possible to interpret the pandemic as an opportunity for city government to find sustainable solutions to improve the living conditions of citizens and the built environment (Ding et al., 2022). The green hanging gardens with public access (e.g. project of the Roof Garden of the Polyclinic of Milan (Boeri Architetti, 2019) with sensorial and chromo-therapeutic paths) can be considered a best practice in the perspective of a broader urban regeneration project. Such improvements in living conditions and quality of neighbourhoods, especially if undertaken in the poorest and most socially deprived contexts, could trigger gentrification processes, by excluding segments of the population from buying or renting houses (Anguelovski et al., 2018; Wolch et al., 2014). The inclusion of green spaces in densely built contexts is mainly aimed at outdoor interventions, which require adequate funding from the government and, at the same time, are often met with the opposition from private owners (Bengston et al., 2004).

Nevertheless, despite the relevant interest in the literature, it must be stressed how research on urban health has been developed especially after Covid-19 pandemic. Therefore, the impacts obtained by the application of technical strategies have been analysed in the last decades exclusively from an environmental point of view while

they may have interesting consequences even from the urban health point of view. A comprehensive approach for the estimation of greening impacts in urban contexts is still lacking, thus giving space to the development of tools able to determine the impacts of green solutions in the increase of urban health. This chapter aims to: outline methods for new urban green space definition in areas with high urban density and very compact fabric; increase urban resilience and health by applying new green solutions (NBSs) in built areas with large urban blocks. The advantages in terms of increased urban health and resilience are estimated indirectly in terms of increase of public green spaces. Looking at existing extensive public buildings thus seems an effective strategy to make greening interventions feasible. Their size, typological features, and spread across the urban territory, even in particularly dense contexts, characterises them as ideal objects for the application of green strategies. Determining a rating of buildings based on their adaptability to undergo transformation interventions may results of help (Diana et al., 2022).

2 Nature-Based Solutions (NBSs)

Epidemiological emergencies, together with climatic ones, increasing urbanisation and ecosystem degradation, pose a challenge to the resilience of urban areas, the quality of life, and the well-being of citizens. By promoting socio-economic development and preserving ecosystems, NBSs provide a way to address these challenges. The application of these technical strategies to increase urban green spaces, can be beneficial, not only from an environmental perspective, but also in terms of quality of life of urban spaces, which has a direct and indirect impact on the citizens' health. Indeed, with the expansion of green and blue areas, the heat island effect decreases and consequently the health of urban spaces is improved through biodiversity (Bayulken et al., 2021). The concept of NBSs is still quite young. It was first introduced by the European Commission in 2015 as "*solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions*" (Ascenso et al., 2021). Later, the International Union for Conservation of Nature (IUCN) defines NBSs as "*actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*" (IUCN). The various definitions highlight how the NBSs aim to address social, environmental, and economic problems in a sustainable way, and integrate solutions inspired, supported, or copied from nature (European Commission, 2016; Faivre et al., 2017; Pauleit et al., 2017).

According to these definitions, most of the scientific literature underlines exclusively the ability of NBSs to mitigate and adapt to the phenomena associated with

climate change. Really, the implementation of NBS in urban contexts implies benefits not only for urban health but also for the health of citizens, especially in times of health emergency as demonstrated by the Covid-19 pandemic. The application of NBSs is thus not only an important technical intervention, but also an instrument for improving the usability of urban spaces by users and for improving urban health.

Combining environmental and social benefits, NBSs offer several advantages: the insertion or increase of urban trees, parks, gardens, green roofs, and green facades, favours the interception of particulate matter, absorbs pollutants, lowers temperatures, and acts as a buffer against flooding (European Environment Agency, 2022). At the same time, they provide opportunities for recreation and social cohesion, creating spaces for socialization and well-being of citizens. In addition, NBSs support biodiversity and species conservation.

The European Commission's report (European Commission, 2015) on NBSs provides examples of how nature can be brought back to cities and degraded ecosystems to improve urban health, and citizens' well-being, thereby promoting climate change adaptation (Faivre et al., 2017). The main NBS solutions at urban scale and their associated beneficial functions, as reported by EC reports, are summarized in Table 1 and shown graphically in Fig. 1.

3 Methodology

The improvement of the quality of existing urban contexts in terms of urban resilience and health is here reached by a clear methodology. Such improvement is calculated as the increased area of public green spaces through the application of NBSs to public buildings. Both new accessible public gardens and meadows, and non-accessible areas with green roofs and facades are computed. Especially in dense urban contests, implementing greening measures on large public urban blocks, both on inner uncovered spaces and building components, seems the privileged procedure for the procurement of additional public green space. Several steps have been identified and collected into two major phases: the first phase collects the analysis of the as built state of the analysed case study; the second phase is referred to the definition of interventions and the analysis of the related impacts.

3.1 As Built Analysis Phase

The steps collected in this phase are: identification of existing green spaces; identification of extensive public urban buildings; calculation of covered and uncovered surfaces; evaluation of historical-architectural value of the buildings analysed and the related transformability; analysis of the accessibility of green spaces.

Table 1 Benefits of NBS applications in urban areas

Possible Nature Based Solutions			
Regulation	ID	Urban settings	Functions
Air quality regulation	A1 A2	Protect urban green spaces Plant trees along streets	Absorb gaseous pollutants and trap particulate matter
Climate regulation	A1	Protect urban green spaces	Store carbon
Water flow regulation	A3	Green roofs and green walls	Facilitate the interception of rainfall
Water purification and waste treatment	A4	Ponds and wetlands	Collect, store and clean water before storing it in streams
Disease regulation	A1 A5	Protect urban green spaces Use permeable surfaces and vegetation	Improve the quality of the air and the environment Promote biodiversity
	A6	Provide bird feeders and promote the establishment of species	Reduce sources of stagnant water Regulation of vector insects
Pollination	A6	Encourage planting of plants from suitable resources and food plants for caterpillars	Promote nesting opportunities
Disaster Risk Reduction	A7 A3 A2 A5	Sustainable Urban Drainage Systems Green roofs and green walls Trees in urban areas Permeable surfaces	Promote the recharge of the aquifer
Soundscape management	A2	Trees and bushes between streets and houses	Hide adverse sounds in public places Provide shelter for songbirds
Health	A7 A7 A6	Attractive green spaces for access Connect the different services (schools, work, housing) through green spaces Increase biodiversity	Improve the quality of life Improve human and urban health

A.1 Identification of existing green spaces

The identification of existing green spaces is the required starting point of all greening interventions at urban scale. Once that the boundary of the intervention area has been defined, existing green spaces such as parks, gardens, lawn areas, trees on draining pavement, parking lots with draining surfaces are calculated. Considering the goals

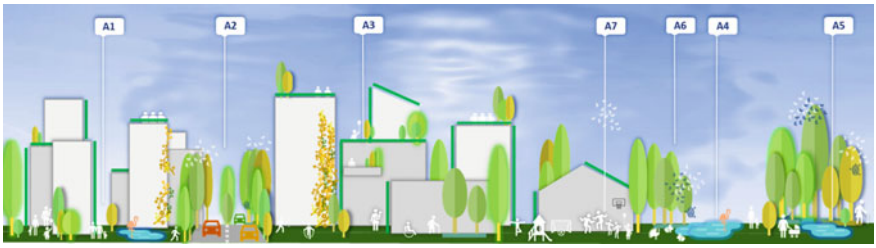


Fig. 1 Nature based solutions in urban areas (*Source* © 2023, Francesco Sommese)

of the present article, only public properties are considered both in terms of green outdoor public spaces and green spaces inside public buildings.

A.2 Identification of extensive public urban buildings

In this step, all the potential areas where greening interventions can be realized are computed. Specifically, lot sizes of public buildings such as healthcare structures and hospitals, schools and universities, administrative offices, and public social housing buildings are considered.

A.3 Calculation of covered and uncovered surfaces

For the lots of buildings computed in step A.2, covered and uncovered surfaces are calculated.

A.4 Evaluation of historical-architectural value

Buildings that have been identified in step A.3 and that are involved in the greening strategies of the considered urban context, may have significant historical, architectural, and cultural limitation to their transformability. Therefore, the considered buildings, throughout a parametric reading of facades, roofs, and courts, are classified based on their readiness to undergo transformation intervention. Indicators considered are related to the ratio between surfaces without any kind of constraint—artistic/architectural or structural—and the whole facade/roof/court surface. A ranking of most transformable buildings is provided.

A.5 Analysis of the accessibility of green spaces

Existing green spaces are not always accessible for external visitors therefore not determining a direct improvement in urban health. The application of NBSs aimed at increasing public green spaces may be triggered especially in those buildings where accessibility is already guaranteed. In this step, only accessible green spaces are considered and calculated based on their current use.

3.2 Intervention Phase

The steps collected in this phase are: definition of new green solutions; calculation of the building reduction impact factor; calculation of new public spaces; calculation of new green spaces; calculation of new accessibility.

B.1 Definition of new green solutions

Once accomplished all the procedures described in Sect. 3.1, it is possible to plan possible greening interventions. By the analysis of results obtained in steps A.1, A.2, and A.3, and after the considerations of steps A.4 and A.5, the surfaces to consider for the application of new green solutions are exactly defined. The new green solutions considered are the NBSs introduced in Sect. 2. The regeneration of large urban buildings, by means of NBSs, determine the transformation of materials of courts, facades, and roofs and allow the access to inner open spaces, often hidden, and difficult to reach to citizens who would appreciate their existing artistic-architectural and environmental qualities while experiencing green and healthy itineraries. In this way the role of open and green spaces in highly urbanised contexts is highlighted.

B.2 Calculation of the building reduction impact factor

The Building Reducing Impact Factor (BRIF)—introduced as RIE in (Comune di Bolzano)—is an environmental quality assessment index, applied to a specific area or building, aimed at certifying the quality of the intervention with respect to the permeability of soil and greenery (Ausiello & Santoro, 2019). This tool is not related to specific climatic conditions and, therefore, it is applicable to any area. The factor is based on the calculation (1). It distinguishes two types of surfaces: green (S_{Vi}) and not green surfaces (S_{ij}). To each of them a specific runoff coefficient (ψ) is assigned based on the permeability of the considered surface. The calculation also considers the equivalent tree surfaces (S_e), defined according to tree height and foliage dimension.

$$BRIF = \frac{\sum_{i=1}^{n} S_{Vi} \frac{1}{\psi} + (S_e)}{\sum_{i=1}^{n} S_{Vi} + \sum_{j=1}^{m} S_{ij} \psi} \tag{1}$$

The index can vary between 0, in the case of completely sealed surfaces with consequent problems to water runoff and surface temperature, and 10, for surfaces without impermeable zones with high performance in terms of water regulation and urban microclimate. The increase of BRIF is calculated for each lot involved in the framework of interventions defined in step B.1.

B.3 Calculation of new public spaces

The intervention planned in step B.1 has a direct impact in enriching the equipment of public spaces in the considered intervention area. The expansion of public spaces to interior open portions of some public buildings is strictly related to accessibility

issues (step A.5). Augmenting the accessibility of inner spaces of buildings should be related to the use of the building itself.

B.4 Calculation of new green spaces

The total green spaces in the considered intervention area are calculated after the definition of interventions. The green spaces here computed are those identified in step A.1 with the addition of those defined in step B.1 such as new green roofs, facades, pavements, and gardens.

B.5 Calculation of new accessibility

The new green spaces introduced in step B.1 imply an augmented accessibility to new public spaces in the inner areas of considered buildings. Nevertheless, some new green spaces are not always accessible to public visitors such as unreachable green roofs or facades. In this final step, only accessible green spaces are calculated. Figure 2 show a graphic workflow of the whole methodology.

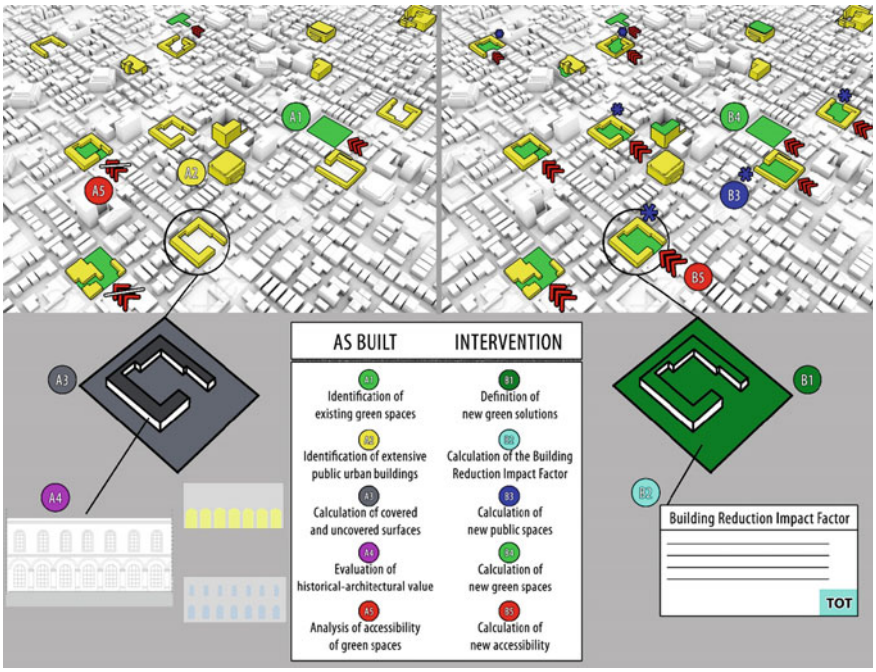


Fig. 2 Graphic workflow of the methodology (*Source*: © 2023, Lorenzo Diana)

4 Case Study

The central areas of the city of Naples evidence a lack of large pedestrian public spaces treated with greenery. However, several historic public buildings show large inner open spaces, courtyards, and cloisters around which buildings are organised. These spaces are often unreachable, either because they are partially or totally abandoned, or because the access is forbidden. The area bounded by corso Umberto, via Duomo, via Foria, via D. Cirillo / via Carbonara / via A. Poerio, Piazza Garibaldi in the Forcella district has been selected as testing area for the development of NBSs (see Fig. 3). The aim is to transform existing courtyards, roofs, and facades, to reopen inner spaces of public buildings to wider itineraries, and to increase the amount of public pedestrian green spaces in a strategic central area with consequences in urban resilience, urban health, and permeability of soils.

The considered area measures approximately 400,000 m^2 and shows a significant lack in the presence of green spaces, becoming an ideal case study for the

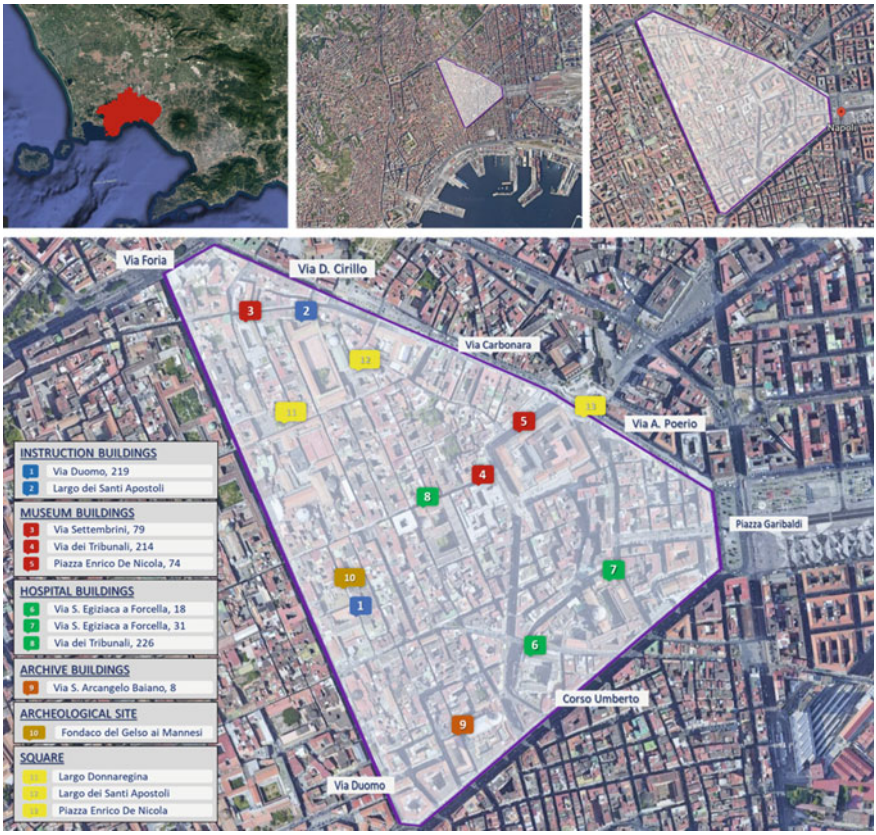


Fig. 3 Case study location (*Source* © 2023, Francesco Sommese; base maps: Google Maps)

application of the methodology proposed in Sect. 3. Within the boundaries of the considered case study, public green gardens and meadows in practice do not exist. Only some flowerbeds with trees can be found in Largo Donnaregina (#11) covering approximately 530 m^2. Considering also inner courtyards of public properties such as schools, museums, hospitals, archives, and archaeological areas, the amount of green spaces rises to only 0.67%—for a total surface of 2,706 m^2 (step A.1). These figures prove the need for intervention on the existing public estate in order to acquire new green spaces. The total surface of public lots (see Fig. 4) is 49,539 m^2 equal to 12% of the total case study surface (step A.2). These public buildings are organized around large, uncovered courts and cloisters which on average represent the 25% of the lot size (step A.3). Lists and quantities of public buildings have been retrieved on the open access database of the Ministry of Economy and Finance, archive drawings, and land register data. The analysed public estate appears to be particularly dated. Some buildings have historical and architectural significance and are even listed by the Ministry of Cultural Heritage thus further analyses are needed to determine the related adaptability to transformation. The SS. Annunziata Monumental Hospital (#7) has been selected as a pilot case study for the parametric deepening of the transformability of courts, roofs, and facades. The hospital is a compact four-story structure organized around two courtyards. It was erected in the fourteenth century and continuous additions occurred until the end of the nineteenth century (Sicignano et al., 2022). Nowadays it is partially abandoned. The building is particularly limited to vertical facade transformations for the presence of valuable and ornamental components that limit the free facade to only 6.80% (Diana et al., 2022) while a higher freedom of intervention can been appreciated concerning the roofs (77.55%) and the courts (68.92%). In fact, if the monumental court should be preserved in its architectural value by limiting major interventions, the second court that nowadays is used essentially as a parking for workers, can undergo deep transformations (step A.4). The analysis of the "*as built*" phase ends with the "*Analysis of accessibility of green spaces*" (step A.5). The accessible green spaces are limited to a surface of 1,114 m^2, equal to 0.28% of total case study surface, and represent around the 40% of the total green spaces since the access to back gardens (#3), school courts (#2), archaeological sites (#10), and some hospital courts (#6) is limited or forbidden.

The intervention phase starts with the definition, on the considered buildings and based on the transformability results of step A.4, of the optimal NBSs. For the pilot case study (#7), considering the artistic value of the monumental courtyard, where already several trees can be found, the focus is on the application of interventions on the secondary courtyard and the building's roofs. The application of the following NBSs was considered: on the secondary courtyard, the existing paving (asphalt) was replaced with drainage paving and second-order trees have been planted; on the top of the building, that is almost exclusively flat, green roofs have been installed in portions free from planting facilities. The application led to an increase in the BRIF from 0.06 to 3.58, resulting in a 35% improvement and guaranteeing the creation of high environmental quality green pedestrian accessible spaces (surface of 1,238 m^2).

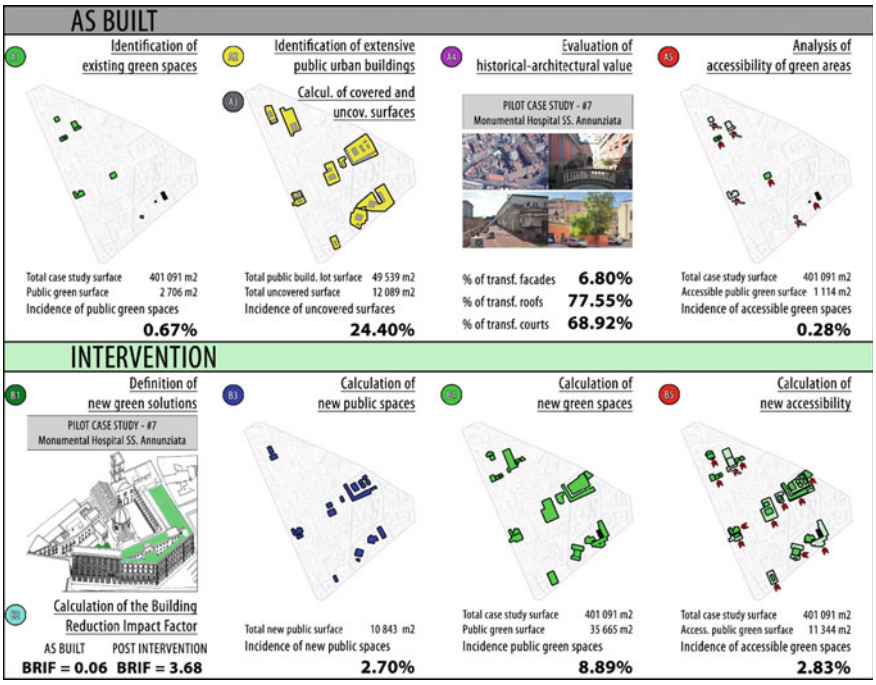


Fig. 4 Application of the methodology to the case study of the centre of Naples (*Source* © 2023, Lorenzo Diana)

This procedure is applied to the nine public buildings considered and on the archaeological site bringing to an augmentation in public space of 10,843 m^2 (step B.3), equal to 2.70% of the total study surface. Such value differs from the uncovered surface of step A.3 since the internal courtyard of the school (#2) cannot be considered as possible public space in case of a wider regeneration intervention. The definition of NBSs leads to a total amount of public green spaces (step B.4) of 35,665 m^2, passing from an incidence of 0.67% to 8.89% on the total case study surface. A large quantity of such new public green spaces are green roofs and therefore most of the time not accessible to common visitors. The accessible green spaces are limited to new courts of considered buildings and small gardens and meadows in public squares (#11, #12, and #13). New accessible green areas amount to totally 11,344 m^2 (step B.5), equal to 2.83% of the total case study surface and strongly higher than the as built figure.

5 Conclusions

The urgent need to provide more accessible public green spaces for psycho-physical well-being of citizens has been greatly demonstrated by the health emergency of the Covid-19 pandemic. The aim of this study is to make urban areas more resilient and improve urban health by implementing the methodological approach described and studied. Large cities, with a high population density, although lacking in public spaces, are configured as privileged places to test the application of NBSs with the aim of directly improving environmental impact—as a result of the purely technical application of these solutions—and indirectly restoring urban health, fostering biodiversity, limiting the transmission of infectious diseases, and creating much healthier living environments. The application of NBSs in highly urbanised contexts can also be considered a good practice for a broader process of urban transformation and regeneration, in line with the European instruments for achieving climate neutrality by 2050.

In hard urban contexts, where it is particularly difficult to find transformable areas for greening intervention in public space, it is necessary to look at large buildings in central areas—such as monumental hospitals, offices, schools, universities, etc.—that go beyond the building scale and take the form of urban blocks. In this way, public buildings prove to be a favourable planning scenario due to their widespread distribution in the urban territory, their large dimensions, and their typological characteristics, as they lend themselves to green transformation interventions and guarantee the provision of a significant number of green spaces thanks to the easy transformation of materials and functions of courtyards and roofs. This becomes trivial in dense historical central areas, as demonstrated in the case study of Naples, where it is possible to go from 2,706 m^2 of green space to more than 13 times that amount (35,665 m^2) by intervening on only nine public buildings, one archaeological site, and three public squares. The results (Sect. 4) show that non-accessible green spaces (24,321 m^2 equal to 68%) are easier to be realized through the construction of green roofs—it must be stressed that considered buildings present mainly flat roofs—while accessible green spaces for citizens are more complex (11,344 m^2 equal to 32%)—it must be underlined that for architectural and historical reasons not all buildings' courtyards can be transformed. Interventions on vertical walls appear even more difficult, as the vertical envelopes of historic buildings in central areas are subject to strict artistic and architectural constraints. In the pilot case study (#7), only 6.80% of the vertical envelope can be transformed, while 77.50% of the roofs and 68.92% of the courtyards can be transformed.

The methodology proposed in this chapter can be a useful tool for researchers to advance studies on improving quality of life and urban health in highly urbanised contexts.

Author Contributions **Conceptualization**: L. Diana & F. Sommese; **Writing**: L. Diana (paragraph 1, 3, 4) & F. Sommese (paragraph 1, 2, 5); **Analysis, Investigation and data curation**: L. Diana & F. Sommese; **Reviewing & editing**: L. Diana & F. Sommese; **Supervision**: F. Polverino & G. Ausiello.

Funding This research was partially funded by the PRIN 2022 PNRR project P2022MNKEC, CUP E53D23019110001.

References

Anguelovski, I., Connolly, J. J. T., Masip, L., & Pearsall, H. (2018). Assessing green gentrification in historically disenfranchised neighborhoods: a longitudinal and spatial analysis of Barcelona. *Urban Geography*, *39*(3), 458–491. https://doi.org/10.1080/02723638.2017.1349987.

Ascenso, A., Augusto, B., Silveira, C., Rafael, S., Coelho, S., Monteiro, A., Ferreira, J., Menezes, I., Roebeling, P., & Miranda, A. I. (2021). Impacts of nature-based solutions on the urban atmospheric environment: a case study for Eindhoven, The Netherlands. *Urban Forestry and Urban Greening*, *57*(May 2020), 126870. https://doi.org/10.1016/j.ufug.2020.126870.

Ausiello, G., & Santoro, E. (2019). What it means to plant a tree. *Sustainable Mediterranean Construction, 2019*(N9), 73–78.

Barbarossa, L. (2020). The post pandemic city: Challenges and opportunities for a non-motorized urban environment. An overview of Italian Cases. *Sustainability (Switzerland), 12*(17), 1–19. https://doi.org/10.3390/su12177172

Bayulken, B., Huisingh, D., & Fisher, P. M. J. (2021). How are nature based solutions helping in the greening of cities in the context of crises such as climate change and pandemics? A comprehensive review. *Journal of Cleaner Production, 288*, 125569. https://doi.org/10.1016/J.JCLEPRO.2020.125569

Bengston, D. N., Fletcher, J. O., & Nelson, K. C. (2004). Public policies for managing urban growth and protecting open space: Policy instruments and lessons learned in the United States. *Landscape and Urban Planning, 69*, 271–286.

Boeri Architetti, S. (2019). *Project Policlinico di Milano*. https://www.stefanoboeriarchitetti.net/project/ospedale-maggiore-policlinico/.

Comune di Bolzano. (n.d.). *RIE Index*. Retrieved December 29, 2022, from https://opencity.comune.bolzano.it/Servizi/Richiedere-la-certificazione-preventiva-R.I.E.-Riduzione-dell-Impatto-Edilizio.

Diana, L., D'Auria, S., Acampa, G., & Marino, G. (2022). Assessment of Disused Public Buildings: Strategies and Tools for Reuse of Healthcare Structures. *Sustainability (Switzerland)*, *14*(4). https://doi.org/10.3390/su14042361.

Ding, A., Cenci, J., & Zhang, J. (2022). Links between the pandemic and urban green spaces, a perspective on spatial indices of landscape garden cities in China. *Sustainable Cities and Society, 85*, 104046. https://doi.org/10.1016/J.SCS.2022.104046

European Commission. (2015). *Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities*. https://doi.org/10.2777/765301.

European Commission. (2016). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of The Regions Next Steps for a Sustainable European future – European Action for Sustainability COM/2016/0739*.

European Environment Agency. (2022). *Urban sustainability in Europe - Post-pandemic drivers of environmental transitions*. https://www.eea.europa.eu/publications/urban-sustainability-drivers-of-environmental.

Faivre, N., Fritz, M., Freitas, T., de Boissezon, B., & Vandewoestijne, S. (2017). Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges. *Environmental Research*, *159*(August 2017), 509–518. https://doi.org/10.1016/j.envres.2017.08.032.

Fong, K. C., Hart, J. E., & James, P. (2018). A review of epidemiologic studies on greenness and health: Updated literature through 2017. *Current Environmental Health Reports, 5*(1), 77–87. https://doi.org/10.1007/S40572-018-0179-Y/TABLES/1

Frantzeskaki, N. (2019). Seven lessons for planning nature-based solutions in cities. *Environmental Science and Policy*, *93*(October 2018), 101–111. https://doi.org/10.1016/j.envsci.2018.12.033.

Geary, R. S., Wheeler, B., Lovell, R., Jepson, R., Hunter, R., & Rodgers, S. (2021). A call to action: Improving urban green spaces to reduce health inequalities exacerbated by COVID-19. *Preventive Medicine, 145*, 106425. https://doi.org/10.1016/J.YPMED.2021.106425

Grădinaru, S. R., & Hersperger, A. M. (2018). Green infrastructure in strategic spatial plans: Evidence from European urban regions. *Urban Forestry & Urban Greening, 40*, 17–28.

Hersperger, A. M., Grădinaru, S. R., Oliverira, E., Pagliarin, S., & Palka, G. (2019). Understanding strategic spatial planning to effectively guide development of urban regions. *Cities, 94*, 96–105.

IUCN. (n.d.). *Nature-based Solutions.* Retrieved December 28, 2022, from https://www.iucn.org/our-work/nature-based-solutions.

Johns Hopkins University. (n.d.). *Corona Virus Research Centre.* Retrieved December 28, 2022, from https://coronavirus.jhu.edu/map.html.

Korpilo, S., Kajosaari, A., Rinne, T., Hasanzadeh, K., Raymond, C. M., & Kyttä, M. (2021). Coping with crisis: green space use in Helsinki before and during the COVID-19 pandemic. *Frontiers in Sustainable Cities, 3*, 99. https://doi.org/10.3389/FRSC.2021.713977/BIBTEX

Lopez, B. (2020). Parks are critical urban Infrastructure: Perception and use of urban green spaces in NYC during COVID-19. *Preprints.* https://doi.org/10.20944/PREPRINTS202008.0620.V1.

Lu, Y., Zhao, J., Wu, X., & Lo, S. M. (2021). Escaping to nature during a pandemic: A natural experiment in Asian cities during the COVID-19 pandemic with big social media data. *Science of the Total Environment, 777*, 146092. https://doi.org/10.1016/J.SCITOTENV.2021.146092

Madhav, N., Oppenheim, B., Gallivan, M., Mulembakani, P., Rubin, E., & Wolfe, N. (2017). Pandemics: Risks, Impacts, and Mitigation. In D. T. Jamison, H. Gelband, S. Horton, J. Prabhat, L. Ramanan, N. M. Charles, & R. Nugent (Eds.), *Disease Control Priorities, Third Edition (Volume 9): Improving Health and Reducing Poverty* (3rd ed., Vol. 9, pp. 315–345). The International Bank for Reconstruction and Development/The World Bank. https://doi.org/10.1596/978-1-4648-0527-1_CH17.

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning, 147*, 38–49. https://doi.org/10.1016/j.landurbplan.2015.11.011

Musco, F. (2009). *Rigenerazione urbana e sostenibilità.* Franco Angeli.

Osservatorio Nazionale Screening. (2020). *RAPPORTO SULLA RIPARTENZA DEGLI SCREENING - SETTEMBRE 2020.* https://www.osservatorionazionalescreening.it/content/rapporto-sulla-ripartenza-degli-screening-settembre-2020

Pauleit, S., Zölch, T., Randrup, T. B., & Konijnendijk van den Bosch, C. (2017). Nature-Based Solutions and Climate Change – Four Shades of Green. In N. Kabisch, H. Korn, J. Stadler, & A. Bonn (Eds.), *Nature-Based Solutions to Climate Change Adaptation in Urban Areas. Theory and Practice of Urban Sustainability Transition.* Springer, Cham. https://doi.org/10.1007/978-3-319-56091-5_3.

Samuelsson, K., Barthel, S., Colding, J., Macassa, G., & Giusti, M. (2020). *Urban nature as a source of resilience during social distancing amidst the coronavirus pandemic.* https://doi.org/10.31219/OSF.IO/3WX5A.

Sicignano, C., Diana, L., Marmo, R., & Polverino, F. (2022). Abandoned places, complexes and parts of cities. Regeneration and enhancement of monumental hospitals in the historic centre of Naples. *VITRUVIO - International Journal of Architecture Tecnology and Sustainability*, *7*(1), 78–91.

Sommese, F., & Diana, L. (2022). Il ruolo degli ospedali monumentali nelle strategie di adattamento al cambiamento climatico. *Urbanistica Informazioni*, *306 s.i.*(2), 132–134.

Sturiale, L., & Scuderi, A. (2019). The role of green infrastructures in urban planning for climate change adaptation. *Climate, 7*(10), 119.

Ugolini, F., Massetti, L., Calaza-Martínez, P., Cariñanos, P., Dobbs, C., Ostoic, S. K., Marin, A. M., Pearlmutter, D., Saaroni, H., Šaulienė, I., Simoneti, M., Verlič, A., Vuletić, D., & Sanesi, G. (2020). Effects of the COVID-19 pandemic on the use and perceptions of urban green space: An international exploratory study. *Urban Forestry & Urban Greening*, *56*. https://doi.org/10.1016/J.UFUG.2020.126888

Venter, Z. S., Barton, D. N., Gundersen, V., Figari, H., & Nowell, M. (2020). Urban nature in a time of crisis: Recreational use of green space increases during the COVID-19 outbreak in Oslo Norway. *Environmental Research Letters, 15*(10), 104075. https://doi.org/10.1088/1748-9326/ABB396

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough.' *Landscape and Urban Planning, 125*, 234–244.

Chapter 4
How Breaks in Nature Can Affect the Users' Wellbeing: An Experience-Based Survey During the Lockdown (COVID-19): Strategies for Healthy and Resilient Green Areas in Our Cities

Marco Gola, Monica Botta, Anna Lisa D'Aniello, and Stefano Capolongo

Abstract In the occasion of COVID-19 pandemic, the life of citizens was greatly disrupted—from healthcare professionals to the smart workers—and consequently also the state of mood. On the basis of the scientific evidence about the relationship between the built environment and health, a research group has promoted an investigation on the benefits that greenery can have on the psycho-physical state of the users, especially healthcare staff and users at home. The methodology adopted is the Profile of Mood States, which provides experiential activity in nature—without any technological distraction- to evaluate the benefits of mood. The methodology adopted refers to the shorter version (34 items) elaborated by prof. Grove at the University of Western Australia. About the COVID-19 pandemic, the experience-based questionnaire was administered to general users in Italy. The questionnaire is composed of a few questions, to be completed before and after an experience in nature of 20/30 min. The investigation requires to be carried out in private gardens, balconies and/or terraces with greenery, public green areas, etc. 225 participants took part to the investigation. Data analysis highlighted the higher performances in anxiety, depression, anger, force, fatigue, and confusion, for users who had the experience in the garden

M. Gola (✉) · S. Capolongo
Politecnico di Milano, Department ABC – Architecture, Built environment and Construction engineering, Design & Health Lab, Milan, MI, Italy
e-mail: marco.gola@polimi.It

M. Botta
Studio Monica Botta, Bellinzago, NO, Italy

M. Botta · S. Capolongo
Politecnico di Milano, postgraduate training course "Therapeutic Landscape Design", Milan, MI, Italy

A. Lisa D'Aniello
Hub4Mind, Varese, VA, Italy

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_4

(-50/70%). Although it is well-known the benefits that nature affects positively on well-being and stress level of users, the investigation underlines that a brief break in nature—especially in a period of great stress such as the pandemic—can influence the well-being and mental health of users. The chapter aims to list and suggest some design strategies for a new approach to the design of healthy cities.

Keywords COVID-19 · Experience-based survey · Experience in nature · Profile of Mood States · Healthy cities

1 Introduction

The recent SARS-CoV-2 pandemic has affected significant upheavals in daily life and, as a consequence, in the users' mood (stress, distraction, anxiety, etc.), especially during the lockdown (Capolongo et al., 2020; Spencer et al., 2020).

As already argued by the Scientific Community, greenery and nature have a very important influence on psycho-physical well-being and a quite influential therapeutic effect on mental health (Botta, 2017; D'Alessandro et al., 2015; Gianfredi et al., 2021).

Among the activities promoted by the Design & Health LAB of Dept. Architecture, Built environment and Construction engineering (DABC) at Politecnico di Milano (Italy), a study was promoted in recent months with a multidisciplinary working group, composed of experts in the field of hospital design and healing gardens, to measure the psycho-physical wellness of people, in a rather stressful moment (Gola et al., 2021), such as the COVID-19 pandemic (Morganti et al., 2022; Cuerdo-Vilches et al., 2020; Signorelli et al., 2020).

For the development of the survey, the administration of an online questionnaire was planned with the scope to assess the benefits that 20/30 min in nature—without technological distractions—can affect the user's psycho-physical conditions. To conduct the investigation, the working group used the Profile of Mood States (POMs) methodology, also known as "mood profile" (White et al., 2019).

The questionnaire was structured for two different populations: one for the healthcare staff (Gola et al., 2021), and the other for the general population. This contribution shows the data analysis related to the general population.

2 State of the Art

In recent decades the relationship between man and nature has been investigated by many scientists (Berto & Barbiero, 2017; Berto et al., 2015). Several studies have led to explain the processes of influence on users' attitudes for defining the importance of nature in the social context (Kaplan & Kaplan, 1995). In particular, our Society—only in recent years—highlighted the need to return to the natural environment.

Among the studies in Japan, several experiments were activated to assess the level of the stress hormone, through the cortisol contained in the saliva of users, with the shinrin-yoku (Li, 2018). This is the practice of walking unhurriedly in a forest, for a short or a long time (Miyazaki, 2018). For several years, few results were obtained, but since the 2000s scientific progress has made it possible to measure the activities of the brain and the autonomic system, allowing defining various parameters and indicators of the level of stress in the human body (Fehr & Capolongo, 2016; Ulrich, 1999). Several scholars, especially in Japan, have begun to study the psychological and physiological effects of the natural environment on human health and well-being (Rousseau & Deschacht, 2020).

The in-depth scientific investigations over the decades have led to the effectiveness of the natural environment on the psycho-physical well-being of users (Kaplan, 1995).

The need for contact with green areas, gardens, terraces, etc. became strong during the lockdown due to the COVID-19 pandemic (Corley et al., 2021; Uchiyama & Kohsaka, 2020; Molaei et al., 2022; Peters & Masoudinejad, 2022). The influence that these areas, whether small or large, affect in terms of wellness, can also be seen in the immersion in nature, also in a few minutes (Capolongo et al., 2020). For improving the knowledge in the field, and starting from the recent extreme emergency, the authors assess the benefits that green can affect the general population, highlighting its importance in living spaces (D'Alessandro et al., 2017).

3 Methodology

To conduct an experience-based study, the working group used the POMs methodology referring to the studies of prof. J.R. Grove (Grove & Prapavessis, 1992).

This methodology requires the user to fill in, before and after the experience in nature, a questionnaire to evaluate the benefits for the user through the scores. It is required to the participant during the survey (Gola et al., 2021):

to fill in the initial questions relating to the user's general information;

to fill in the questions related to the 34 items of POMs, before the experience in nature;

to have the experience in nature (20/30 min, without any technologies);

to fill the questions related to the 34 items of POMs, after the experience in nature.

To process all the information, it was necessary to fill in the questionnaire in its entirety.

In addition to general information about the users (initials of name and surname, date of birth, and gender), the sections to be filled in requested:

employment (employee, self-employed, retired, unemployed, student, etc.);

type of workspace (headquarters/company/office, site construction, smart working, etc.);

presence of a garden and/or green area in the current working area (yes, no);

green space in which the experience-based was conducted (shared garden, private yard, garden or public park, balcony or green terrace).

The research work refers to Robert J. Grove previous studies with the same list of 34 criteria (Grove & Prapavessis, 1992). Unlike the study of prof. Grove, the issue "furious" has been moved from the macro-area "Force" to "Anger", due to incorrect translation by the working group (in the Italian language the term "furious" has a negative meaning instead of "frenetic" and/or "impetuous", as the original questionnaire suggested) (Gola et al., 2021) (Table 1).

The order of the 34 emotions is defined by the method adopted (Grove & Prapavessis, 1992). Many of them are very similar and the choice to use synonymous terms is inherent in the methodology. These different adjectives refer to six macro-areas of mood:

anxiety: tense, on edge, uneasy, restless, nervous, anxious (24 points);

depression: unhappy, sad, lacking hope, discouraged, miserable, helpless, worthless (28 points);

anger: angry, grumpy, annoyed, resentful, bitter, furious (24 points);

force: lively, active, energic, energized, vigorous (20 points);

fatigue: worn-out, fatigued, exhausted, weary, drained (20 points).

confusion: confused, unable to concentrate, bewildered, forgetful, uncertain about things (20 points).

Each macro-area is associated with different scores. 4 points are associated with each mood state (Grove & Prapavessis, 1992).

During the survey, each participant filled in all the items twice: before and after the survey in the green area. The investigation was disseminated through social networks and web pages of institutions involved in the research. The working group aimed to administer the questionnaire to a representative number of users, equal to 600, but in total 225 participants joined the survey.

4 Discussion and Implications

Comparison by type of work activity carried out during the lockdown

The fundamental data that emerges from the analysis is that 59% (132 participants) worked in smart working, 13% (40 ones) in their working station and/or on-site, and 28% answered "other" (users on maternity leave, unemployed, retired, housewives, etc.). In general, it can be said that for many people smart work represented an important improvement in well-being as they feel practically free to work as they see fit. For these people, the performances and their moods will be at the top.

However, for other people, this mode has generated a sense of abandonment. Alone in their homes perhaps without being able to have contact with nature and with other people, they could gradually go into "burn-out" (Fig. 1).

Table 1 List of 34 items of POMs, with their respective scores that the user can choose. Table reworked by Grove and Prapavessis (1992)

State of the mood		Not at all	A little	Moderately	Quite a lot	Extremely
		0	1	2	3	4
Tense	ANX	0	1	2	3	4
Angry	ANG	0	1	2	3	4
Worn-out	FAT	0	1	2	3	4
Unhappy	DEP	0	1	2	3	4
Lively	FOR	0	1	2	3	4
Confused	CON	0	1	2	3	4
Sad	DEP	0	1	2	3	4
Active	FOR	0	1	2	3	4
On edge	ANX	0	1	2	3	4
Grumpy	ANG	0	1	2	3	4
Energic	FOR	0	1	2	3	4
Lacking of hope	DEP	0	1	2	3	4
Uneasy	ANX	0	1	2	3	4
Restless	ANX	0	1	2	3	4
Unable to concentrate	CON	0	1	2	3	4
Fatigued	FAT	0	1	2	3	4
Annoyed	ANG	0	1	2	3	4
Discouraged	DEP	0	1	2	3	4
Resentful	ANG	0	1	2	3	4
Nervous	ANX	0	1	2	3	4
Miserable	DEP	0	1	2	3	4
Bitter	ANG	0	1	2	3	4
Exhausted	FAT	0	1	2	3	4
Anxious	ANX	0	1	2	3	4
Helpless	DEP	0	1	2	3	4
Weary	FAT	0	1	2	3	4
Energized	FOR	0	1	2	3	4
Bewildered	CON	0	1	2	3	4
Furious	ANG	0	1	2	3	4
Worthless	DEP	0	1	2	3	4
Forgetful	CON	0	1	2	3	4
Vigorous	FOR	0	1	2	3	4
Uncertain about things about things	CON	0	1	2	3	4
Drained	FAT	0	1	2	3	4

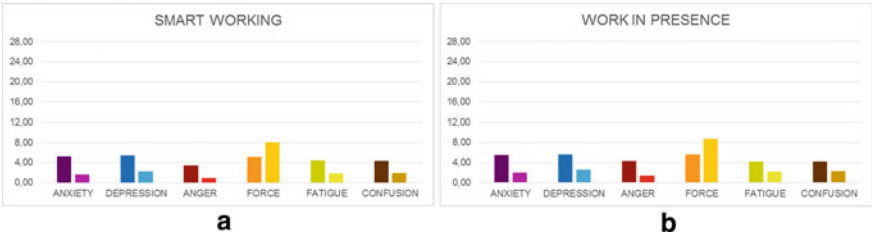


Fig. 1 **a** and **b** Results of the Macro-areas divided between users in smart working and at work in presence. Graphs elaborated by the authors

From the data analysis, the survey shows that the general trends of the 6 macro-categories are similar. An important observation is dutiful on the state of mind of the "Force" generated by green spaces, where the team notices a surge in the relative value of the people who worked on site. It is as if, not having the full availability of time, the moment they can access it, they benefit more than the smart workers who always have green space available.

Comparison by type of occupation of the participants

From the data analysis, it emerges that 64% (143 participants) of the population were employees and self-employed workers, defined as "workers", while the remaining 36% (82 participants) are divided between retired, housewives, students, the unemployed, and those who answered "other", defined as "unemployed".

It was decided to divide these two groups thinking about the flexibility of the use of their own time. The group identified as "workers" has limited time availability and is tied to working hours, unlike the "unemployed" group. From an initial examination, it is clever that the general trends of the 6 macro-categories are similar (Fig. 2).

The choice to subdivide the population into these two macro-areas permits highlight how the unemployed have had greater benefits in the experience of contact with nature although the values are almost aligned.

The "Force" assumes a very important role: it is as if nature has allowed people to recover that strength and lucidity that everyday life had somewhat forgotten. Finding the scope, albeit limited and momentary to the survey, has raised this value to 69%.

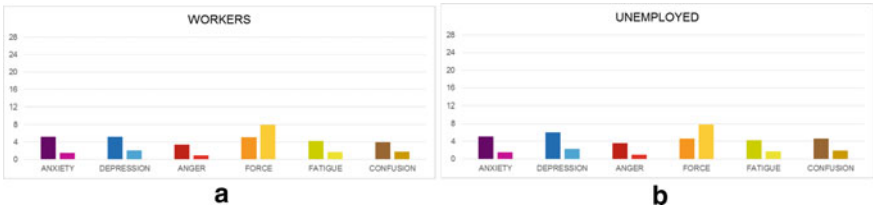


Fig. 2 **a** and **b** Outcomes of the Macro-areas divided into workers and unemployed. Graphs elaborated by the authors.

Comparison by gender and age groups

The data that emerges from the analysis is that 24% (55 participants) of the population is under 30 years, 52% (117) is between 30 and 60 years old and 18% (41) is over 60 years of age. It is also recorded that 5% (12) did not indicate their age. This population, not being representative, was excluded from this comparison; in the same way, users who answered "I prefer not to answer" regarding gender was excluded.

Therefore, as the Figures show, the analysis conducted takes into consideration the responses of the participants divided into men and women, subdivided by age groups. The letters "F" and "M" correspond respectively to "female" and "male".

From an initial examination, it is observed that the general trends of the 6 macro-categories are similar more evidence are related to the female population over 60 years of age (Fig. 3).

The environment influences people's state of well-being and how immersion in nature for at least 20 min is affecting positively for everyone, especially women over 60 (Corley et al., 2021). This new habit must be acquired and administered consciously to all people, regardless of age group, for the protection and prevention of well-being and mood.

There are "thinking styles" that naturally predispose us to stress so it is necessary both to know them and to implement behaviors that allow people to overcome this

Fig. 3 **a–f** Results of the Macro-areas subdivided between men/women and age group. Graphs elaborated by the authors

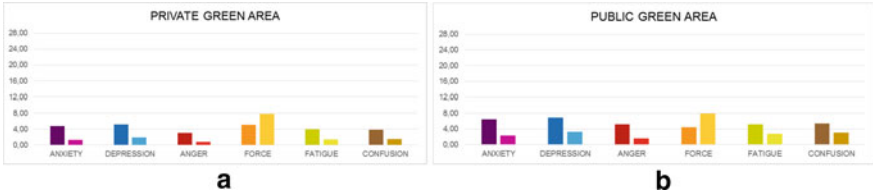


Fig. 4 **a** and **b** Results of the Macro-areas divided into types of public and private green areas. Graphs elaborated by the authors

condition. For example, people who like to immerse themselves in their home garden every day had not suffered from the lockdown as people who like to access and benefit from nature each time in a different place (more variable). For these people, even having only a private garden or their own spaces available, was very restrictive.

Comparison by type of green used for the survey

From the data analysis, it emerges that 80% (179 participants) of the population surveyed a private green area, and the remaining 20% in a public area (public park, a shared garden, company garden, etc.).

This fragmentation of the type of green has allowed us to better analyze the data in our possession. The private green area includes the garden and the terrace, an intimate area for the exclusive use of the person who participated in the survey. On the contrary, the public green area is not for the exclusive use of people, who have to share the space with other "strangers" (Fig. 4).

An initial examination shows that the general trends of the 6 macro-categories are similar.

The data collected demonstrates how essential the possibility of using a private green space: either as a balcony or garden. It is evident that people who can use this space are favored in a better basic emotional state; provided that this space is habitually used consciously. This space, for the people who live in it, is an integral part, guaranteeing a solid starting point (Peters & Masoudinejad, 2022; Ugolini et al., 2020).

It is therefore clear that people with can only use public parks, have lower starting values but find their greatest exception, once again, in "force".

5 Concluding Remarks and Design Strategies for a New Approach for Healthy Cities

General considerations

The survey was structured on the six macro emotional categories (anxiety, depression, anger, fatigue, confusion, and force), and between before and after the immersion in the green area, in general, all the users had benefits with an indicative improvement

average of 50–60%, particularly in young people under 30 and in women over 60, while males over 60 are those who recorded the lowest values. In terms of force, the female population over 60 and under 30 observes peaks of 100%, and items such as 'lively' and 'vigorous' record values of 150 and 250% improvement compared to the initial response, instead in terms of anxiety and tiredness, the greatest benefits are recorded for the population in smart working compared to the workers on site, which highlights that in a phase of stress, such as that of the lockdown, those who have been forced to interrupt their daily habits, they benefited particularly during the experience in nature. In terms of 'Force', the highest values were recorded in the unemployed. As far as the type of greenery is concerned, in general, those who have used a private green area have had the greatest benefits, in terms of reduction of anxiety, depression, tiredness, and confusion, but even those who have lived in public green areas have had significant benefits in terms of force with peaks equal to 100% in 'lively' and 'stimulated'.

Users have found their maximum benefit in a green area, reaching greater calm and force. In this lapse of time, we could mention some thinking styles (referring to Sternberg) involved such as "relationship and tasks": this time was necessary for those who prefer relationships, to regenerate in nature with the presence of some colleagues; others may have been used to regain force and continue to do what they were doing. Styles influence each other.

Starting from a general analysis, it is clever how force acquires important values. The information collected outdoors is processed only through senses (sight, hearing, touch, taste, and smell) so the users analyze this data using these styles (Sachs, 2020). Specifically, getting in touch with nature activates all these senses. The person who prefers the sight will therefore notice all the different colors of the plants and flowers. The users who prefer hearing will notice all the sounds, noises, or the absence of noise (ward trolleys, steps, patient bells, etc.). Kinesthetic people (who prefer touch, taste, and smell sensations) will perceive more emotions when they are immersed in nature (touching the ground, or smelling the scent of plants).

Critical aspects of the investigation

The study highlights the great influence that nature can have on the well-being of users, even in a short time (White et al., 2019). Although the number of questionnaires was limited to more than 200 participants, the data processed are rather representative and supportive to develop useful considerations. In any case, the working group undertakes, for possible future similar episodes, to conduct the investigation again to expand the number of questions and get more detailed information to better support the data analysis.

In particular, starting from a general examination and various comments by the participants to the questionnaire, it is considered appropriate to supplement the questionnaire with the following information: a) geographical location of the user and urban context in which the survey was carried out; b) duration of the break dedicated to the experience in nature; c) specifications on the user's day and possible factors that may justify the presence of anomalous data; d) specifications relating to the space in which the survey was conducted and possible distracting and/or disturbing

factors; e) state of the green area in which the survey was conducted; f) activities carried out during the investigation (Kaplan, 1973); g) sensory activity.

New strategic lines: design strategies for a new approach to the design of healthy cities

Numerous studies have demonstrated how visibility in natural environments can affect physical and mental health. Although, as highlighted by some researchers, the view into a green area (a garden or park, greenery, green roofs, etc.) can improve the well-being of users (Buffoli et al., 2018; Gola et al., 2020; Grappasonni, 2018), the study has shown how—even in a brief break—a moment in the green can regenerate users, especially in times of stress.

The presence of green elements, in addition to having an important role in mitigating the impacts of the built environment on climate change and improving the ecological-climatic conditions of cities, brings a wide range of health benefits for all age groups (Appolloni et al., 2019; Engemann et al., 2019; Rebecchi et al., 2019). One of its main effects is the alleviation of the urban climate, helping to reduce the health impacts of heat waves, increase the moisture content in the air, and lower the temperature in hotter periods (Buffoli et al., 2022; Capolongo et al., 2018). In the absence of greenery, depending on the morphological characteristics of the city, the average maximum summer temperatures can be 1–3 times higher than in rural environments, with possible greater variations, especially at night (Solfani et al., 2018).

The study conducted demonstrated how—even for a short time—a break in nature can regenerate users, especially in times of stress.

From the data analysis, it is observed that for many users the values ranged between the values 0 (not at all)/1 (a little)/2 (enough), and therefore, on average, the values did not register particular differences, although the percentages are emblematic because they have reductions equal to 60/70/80% between the before and after the survey. The reduced values, even from a direct sharing of ideas with some participants in the survey, are often associated with the presence of many emotions that are very similar to each other and in some cases somewhat extreme, such as “furious”, “dejected” and “exhausted”. In any case, the difference in the answers before and after the investigation highlights the effects that a brief break in the green can affect on well-being. As the EBD studies demonstrated, the presence of spaces for psychophysical well-being is strategic for all users (Sachs, 2020).

Although the number of questionnaires was limited to more than 200 participants, the data processed are rather representative and supportive in developing useful considerations.

It is observed that within the general population, which has been forced to “stay at home”, they have transformed their living environments into a place for leisure, work, study, physical activity, etc. testing the flexibility, versatility, and resilience of the spaces, and those in possession benefited from their own outdoor spaces (D’Alessandro et al., 2020).

Based on experience, the new trends in residential buildings will require the presence—at least—of a balcony for each apartment in the building regulations. Green

elements offer more opportunities to practice physical and recreational activities, thus helping to promote well-being and social inclusion, as well as reducing the frequency of various pathologies such as coronary heart disease, skeletal disorders, anxiety, depression, diabetes, etc. (Maas et al., 2009).

Equally interesting is the role of gardening, both in terms of education and well-being. This activity increases in psychological terms the individual force, strength, psychological well-being, relationships with others, sense of community, and cognitive function, especially in certain age groups (Soga et al., 2017). It also helps to reduce stress, anger, fatigue, depression, and anxiety (Wood et al., 2016). In addition, where it is not possible to have a private garden, a shared garden, or a terrace/balcony, the presence of a green facade or a view of park areas, trees, or green roofs could be partially optimal (Buffoli & Carli, 2012).

Similar considerations need to be taken into consideration also for the design of urban green areas. It is well-known that there are several advantages for the Community both for Public Health issues (physical, social, and psychological), the environment, and its resilience to climate change (Buffoli et al., 2022; Rebecchi et al., 2016; Shoari et al., 2020; Romano-Spica et al., 2015).

However, the current metropolises still lack an overall vision of green management capable of guaranteeing safe, qualitative, accessible, and equally distributed green areas throughout the territory (Capolongo et al., 2015; Oppio et al., 2020). Currently, several Countries have various municipal tools for mapping and managing Urban Green Spaces such as the Green Census, Regulations, Plans, etc. but they are often made of incomparable methodological information, and typically with quantitative information (Buffoli et al., 2020). Therefore, the greenery quantity presence in an area is not the representative factor for offering adequate green infrastructures for the Community.

Green Spaces represent a fundamental component of the public spaces and common services provided by a city. For greater social equity, and inclusion, it is necessary to ensure adequate territory distribution and quality, both in terms of design and services, and to verify accessibility for all (Davis et al., 2009; Dominelli, 2021).

Acknowledgements The working group would like to thank all those who took part to the experience-based survey and the time they spent, and those who supported the investigation in its dissemination through social channels and mailing lists.

References

Appolloni, L., Corazza, M. V., & D'Alessandro, D. (2019). The pleasure of walking: An innovative methodology to assess appropriate walkable performance in urban areas to support transport planning. *Sustainability, 11*(12), 3467.

Berto, R., & Barbiero, G. (2017). The biophilic quality index: A tool to improve a building from "green" to restorative. *Vision for Sustainability, 8*, 38–45.

Berto, R., Barbiero, G., Pasini, M., & Unema, P. (2015). Biophilic Design triggers fascination and enhances psychological restoration in the urban environment. *Journal of Biourbanism, 1*, 26–35.
Botta, M. (2017). La vegetazione e la sua componente terapeutica. *Medicina Integrata, 6*, 52–56.
Buffoli, M., Carli, P. (2012). Skyland, vertical farming in Milan. *Territorio, 60,* 49–54.
Buffoli, M., Rebecchi, A., Dell'Ovo, M., Oppio, A., Capolongo, & S. (2020). Transforming the built environment through healthy-design strategies: a multidimensional framework for urban plans' evaluation. In: Bevilacqua, C., Calabro, F., Della Spina, L. (Eds.), *New metropolitan perspectives. NMP 2020. Cham, Switzerland: smart innovation, systems and technologies*, 177 SIST: 187–196.
Buffoli, M., Rebecchi, A., Gola, M., Favotto, A., Procopio, G.P., & Capolongo, S. (2018). Green soap. A calculation model for improving outdoor air quality in urban contexts and evaluating the benefits to the population's health status. In: Mondini, G., Fattinnanzi, E., Oppio, A., Bottero, M., & Stanghellini, S. (Eds.), *Integrated evaluation for the management of contemporary cities* (pp. 453–467). Cham, Switzerland: Green Energy and Technology.
Buffoli, M., Villella, F., Voynov, N. S., & Rebecchi, A. (2022) *Urban green space to promote urban public health: Green areas' design features and accessibility assessment in Milano City, Italy*. Lecture Notes in Networks and Systems, 482 LNNS: 1966–1976.
Capolongo, S., Buffoli, M., & Oppio, A. (2015). How to assess the effects of urban plans on environment and health. *Territorio, 73*, 145–151.
Capolongo, S., Rebecchi, A., Dettori, M., Appolloni, L., Azara, A., et al. (2018). Healthy design and urban planning strategies, actions, and policy to achieve salutogenic cities. *IJERPH, 15*(12), 2698.
Capolongo, S., Rebecchi, A., Buffoli, M., Appolloni, L., Signorelli, C., Fara, G. M., & D'Alessandro, D. (2020). COVID-19 and Cities: From Urban Health strategies to the pandemic challenge. A Decalogue of Public Health opportunities. *Acta Biomedica, 2*, 13–22.
Corley, J., Okely, J. A., Taylor, A. M., Page, D., Welstead, M., et al. (2021). Home garden use during COVID-19: Associations with physical and mental wellbeing in older adults. *Journal of Environmental Psychology, 73*, 101545.
Cuerdo-Vilches, T., Navas-Martín, M. Á., & Oteiza, I. (2020). A mixed approach on resilience of spanish dwellings and households during covid-19 lockdown. *Sustainability, 12*(23), 11–24.
D'Alessandro, D., Arletti, S., Azara, A., Buffoli, M., Capasso, L., et al. (2017). Strategies for disease prevention and health promotion in urban areas: The Erice 50 charter. *Annali di Igiene, 29*(6), 481–493.
D'Alessandro, D., Buffoli, M., Capasso, L., Fara, G. M., Rebecchi, A., & Capolongo, S. (2015). Green areas and public health: Improving wellbeing and physical activity in the urban context. *Epidemiologia & Prevenzione, 39*(5), 8–13.
D'Alessandro, D., Gola, M., Appolloni, L., Dettori, M., Fara, G. M., et al. (2020). COVID-19 and living space challenge. Well-being and public health recommendations for a healthy, safe, and sustainable housing. *Acta Biomedica, 91*, 61–75.
Davis, J. L., Green, J. D., & Reed, A. (2009). Interdependence with the environment: Commitment, interconnectedness, and environmental behavior. *Journal of Environmental Psychology, 29*(2), 173–180.
Dominelli, L. (2021). A green social work perspective on social work during the time of COVID-19. *International Journal of Social Welfare, 30*(1), 7–16.
Engemann, K., Pedersen, C. B., Arge, L., Tsirogiannis, C., Mortense, P. B., & Svenning, J. C. (2019). Residential green space in childhood is associated with lower risk of psychiatric from adolescence into adulthood. *Proceedings of the National Academy of Sciences USA, 116*(11), 5188–5193.
Fehr, R., & Capolongo, S. (2016). Healing environment and urban health. *Epidemiologia & Prevenzione, 40*(3–4), 151–152.
Gianfredi, V., Buffoli, M., Rebecchi, A., Croci, R., Oradini-Alacreu, A., et al. (2021). Association between urban greenspace and health: A systematic review of literature. *IJERPH, 18*(10), 5137.

Gola, M., Botta, M., D'Aniello, A. L., & Capolongo, S. (2021). Influence of nature at the time of the pandemic: An experience-based survey at the time of SARS-CoV-2 to demonstrate how even a short break in nature can reduce stress for healthcare staff. *HERD, 14*(2), 49–65.

Gola, M., Capasso, L., Mondoni, G., Petronio, M., Rebecchi, A., Buffoli, M., Appolloni, L., & Capolongo, S. (2020). From building regulations and local health rules to the new local building codes: A national survey in Italy on the prescriptive and performance requirements for a new performance approach. *Annali Di Igiene, 32*(5 Suppl. 1), 36–51.

Grappasonni, I. (2018). *Clean and healthy—Built environments and health: Quality of life in an urban context*, (pp. 183–193). Urban Book Series.

Grove, J. R., & Prapavessis, H. (1992). Preliminary evidence for the reliability and validity of an abbreviated Profile of Mood States. *International Journal of Sport Psychology, 23*, 93–109.

Kaplan, R. (1973). Some Psychological Benefits of Gardening. *Environment and Behavior, 5*(2), 145–161.

Kaplan, S. (1995). The restorative effects of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*, 169–182.

Kaplan, S., & Kaplan, R. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*(3), 169–182.

Li, Q. (2018). *Shinrin-yoku, immergersi nei boschi*. Rizzoli, Milan.

Maas, J., Verheij, R. A., de Vries, S., Spreeuwenberg, P., Schellevis, F. G., & Groenewegen, P. P. (2009). Morbidity is related to a green living environment. *Journal of Epidemiology and Community Health, 63*, 967–973.

Miyazaki, Y. (2018). Shinrin-yoku, La teoria giapponese del bagno nella foresta per ritrovare il proprio equilibrio. Gribaudo-Feltrinelli, Milano.

Molaei, P., Hashempour, P., & Tang, L. M. (2022). Semi-open spaces of apartments considering COVID-19 pandemic: General expectations of balcony design in the post-pandemic world. *Architectural Engineering and Design Management, 18*(5), 705–722.

Morganti, A., Brambilla, A., Aguglia, A., Amerio, A., Miletto, N., et al. (2022). Effect of Housing Quality on the Mental Health of University Students during the COVID-19 Lockdown. *IJERPH, 19*(5), 2918.

Oppio, A., Bottero, M., Dell'Anna, F., Dell'Ovo, M., Gabrielli, L. (2020). Evaluating the urban quality through a hybrid approach: Application in the Milan (Italy) city area. In: Gervasi, O. et al. (Eds), *Computational Science and Its Applications—ICCSA 2020. ICCSA 2020* (vol. 12253). Lecture Notes in Computer Science. Springer, Cham.

Peters, T., & Masoudinejad, S. (2022). Balconies as adaptable spaces in apartment housing. *Buildings and Cities, 3*(1), 265–278.

Rebecchi, A., Boati, L., Oppio, A., Buffoli, M., & Capolongo, S. (2016). Measuring the expected increase in cycling in the city of Milan and evaluating the positive effects on the population's health status: A community-based urban planning experience. *Annali di Igiene, 26*(6), 381–391.

Rebecchi, A., Buffoli, M., Dettori, M., Appolloni, L., Azara, A., Castiglia, P., D'Alessandro, D., & Capolongo, S. (2019). Walkable environments and healthy urban moves: Urban context features assessment framework experienced in Milan. *Sustainability, 11*(10), 2778.

Romano-Spica, V., Macini, P., Galeone, D., Liguori, G., Signorelli, C., Marensi, L., et al. (2015). Adapted physical activity for the promotion of health and the prevention of multifactorial chronic diseases: The Erice charter. *Annali di Igiene, 27*(2), 406–414.

Rousseau, S., & Deschacht, N. (2020). Public awareness of nature and the environment during the COVID-19 crisis. *Environmental and Resource Economics, 76*(4), 1149–1159.

Sachs, A.N. (2020). Access to Nature Has Always Been Important; With COVID-19, It Is Essential. *HERD, 13*(4), 242–244.

Shoari, N., Ezzati, M., Baumgartner, J., Malacarne, D., & Fecht, D. (2020). Accessibility and allocation of public parks and gardens in England and Wales: A COVID-19 social distancing perspective. *PLoS ONE, 15*(10), e0241102.

Signorelli, C., Capolongo, S., D'Alessandro, D., & Fara, G. M. (2020). The homes in the COVID-19 era. How their use and values are changing. *Acta Biomedica, 91*, 92–94.

Soga, M., Gaston, K. J., & Yamaura, Y. (2017). Gardening is beneficial for health: A meta-analysis. *Preventive Medicine Reports, 5*, 92–99.

Soltani, A., & Sharifi, E. (2017). Daily variation of urban heal island effect and its correlation to urban greenery: A case study in Adelaide. *Frontiers of Architectural Research, 6*(4), 529–538.

Spencer, L. H., Lynch, M., Lawrence, C. L., & Edwards, R. T. (2020). A scoping review of how income affects accessing local green space to engage in outdoor physical activity to improve well-being: Implications for post-COVID-19. *IJERPH, 17*(24), 9313.

Uchiyama, Y., & Kohsaka, R. (2020). Access and use of green areas during the covid-19 pandemic: Green infrastructure management in the "new normal." *Sustainability, 12*(23), 9842.

Ugolini, F., Massetti, L., Calaza-Martínez, P., Cariñanos, P., Dobbs, C., et al. (2020). Effects of the COVID-19 pandemic on the use and perceptions of urban green space: An international exploratory study. *Urban Forestry and Urban Greening, 56*, 126888.

Ulrich, R. S. (1999). Effects of gardens on health outcomes: Theory and research. In C. C. Marcus & M. Barnes (Eds.), *Healing gardens: Therapeutic benefits and design recommendations* (pp. 27–85). John Wiley.

White, M. P., Alcock, I., Grellier, J., et al. (2019). Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Science and Reports, 9*, 7730.

Wood, C. J., & Pretty, G. J. M. (2016). A case-control study of the health and well-being benefits of allotment gardening. *Journal of Public Health (Oxford, England), 38*(3), e336–e344.

Chapter 5
Tactical Urbanism as an Innovative Urban Governance Tool: Lessons from the COVID-19 Pandemic

Nina Alvandipour

Abstract The COVID-19 pandemic has disproportionately impacted urban communities, particularly those with vulnerable populations, prior inequalities, and poverty. Tactical Urbanism (TU), characterized by short-term, low-cost, scalable interventions with a vision for long-term change, has gained attention as a means of promoting urban resiliency in the built environment. Viewing through the lens of urban governance, this chapter introduces TU as an open and collective innovation ecosystem in the real-life setting that has the potential to tackle some of the long-standing local problems in the post-pandemic era. The chapter provides an overview of TU practice and research by reviewing academic and grey literature, as well as studying various TU examples implemented in public open spaces after the COVID-19 outbreak. The main aim of this study is to understand the factors that have made TU an increasingly relevant and widely used approach in public open space transformation during the COVID-19 pandemic. By examining the driving forces behind its recognition and adoption, we hope to shed light on the potential value of TU as a powerful governance tool for fostering innovation in urban environments. The way that short-term, low-cost, unsanctioned innovations can eventually lead to sanctioned practices demonstrates the importance of TU in enabling bottom-up initiatives to inform top-down processes. Through active participation, experimentation, and co-creation, this approach can help ensure that public space interventions are responsive to the needs of the community, particularly underserved communities. And as a result, it can contribute to the co-creation of more resilient and equitable cities under uncertainty.

Keywords Tactical urbanism · Urban governance · Public open spaces · innovation · Co-creation · Covid-19

N. Alvandipour (✉)
School of Public Administration, University of Central Florida, Orlando, USA
e-mail: nina.alvandipour@ucf.e

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_5

1 Introduction

The COVID-19 pandemic has disproportionately impacted urban communities around the world, particularly those with vulnerable populations, prior inequalities, and poverty (Smart Growth America, 2022a, 2022b). These communities have faced with various challenges such as population density, lack of access to green spaces, increased air pollution, limited access to health care, and high rates of chronic illnesses (Guterres, 2020; UN-Habitat, 2021). Despite the widespread disruption caused by the pandemic, there has been a renewed focus on transforming public open spaces as a means of promoting urban resilience in the built environment (ITDP, 2020; Majewska et al., 2022). As a result, city leaders, policymakers, community members, and practitioners have started employing various strategies and tools to support public spaces and keep their communities alive and sustained during the pandemic (ITDP, 2020; Smart Growth America, 2022b).

One of the innovative solutions that has gained attention for its flexibility and creativity is *Tactical Urbanism*. TU interventions, which are characterized by low-cost, temporary, and easily implemented actions with a vision for long-term interventions, played a critical role in helping communities face the challenges of the COVID-19 pandemic (Kim, 2022; Lydon et al., 2015; Stevens et al., 2021). The TU movement regained prominence during the pandemic, as it allowed for a re-examination of the relationship between communities, places, and public service delivery (Andres, 2021). During the COVID-19 outbreak, TU interventions such as *Open Streets, Slow Streets, Healthy Streets* have served as models for developing pedestrian and bicycle networks to slow the spread of COVID-19 and ensure social distancing. After the pandemic, interventions like *Urban Play* and *Pop-up Parklets* have provided settings and platforms for community connection and safe social wellbeing.

The focus on TU projects at the community level during the COVID-19 pandemic has increased its potential to be viewed as an innovative solution to long-standing local problems in the post-pandemic era (see Gehl, 2021; NACTO, 2021; Smart Growth America, 2022a, 2022b). The chapter provides an overview of TU practice and research by reviewing academic and grey literature, as well as studying various TU examples implemented in public open spaces, particularly streets in response to the COVID-19 outbreak. This chapter aims to investigate and understand the driving forces behind the relevance and suitability of TU as an innovative urban governance tool during the pandemic and offer insight into how and why this is possible. It is designed to explore TU as an open and collective innovation ecosystem in real-life public open spaces through the lens of urban governance.

The chapter will begin with a background on TU, including an overview of the concept and its evolution during the COVID-19 pandemic. After that, I will discuss some examples of TU that have emerged in response to the pandemic. Next, I will examine TU's enabling and innovative role in urban governance, resulting from the review of previously mentioned examples. Finally, I will summarize with some

remarks and implications for the future of TU as an innovative urban governance tool in the context of the pandemic and beyond.

2 Background

2.1 A Brief Overview of Tactical Urbanism

The TU approach, also known by other names such as *action planning*, do-it-yourself (DIY) *urbanism, planning-by-doing, urban acupuncture, urban prototyping, guerrilla urbanism, pop-up urbanism, city repair* (Kim, 2022; Stevens et al., 2021), originated in academic literature with the publication of a book by Mike Lydon and Anthony Garcia in 2010. The movement also has roots in activist interventions during the 1995–2000 period as a way to protest and demonstrate against injustice in cities (Bike Curious, 2017).

TU involves low-cost, decentralized, and participatory initiatives that transform public spaces in a human-centred and agile way (Kim, 2022). TU projects have roots in active collaboration of community residents or the innovative work of formal entities, such as businesses, and non-profit organizations, local authorities. Either way, it is crucial that TU projects are initiated based on the needs of the community (Lydon et al., 2015). This approach allows local stakeholders to test new ideas without committing a lot of resources, allowing both the city and its residents to see the real impact of their actions and make informed decisions (da Cruz MOSCARELLI, 2020).

Since actions speak louder than words, for community residents, TU is a way to demonstrate their real needs and to draw attention to perceived shortcomings in policy and practice. Cities on the other hand can use TU to engage with people on the ground and rebuild the trust. For advocacy organizations, it is a way to gain public and political support. And, for private-sector, developers, or entrepreneurs, it provides a means of gathering knowledge from the market they want to serve (Kim, 2022; Lydon et al., 2015; Smart Growth America, 2022a, 2022b).

TU actions can vary in terms of legality, duration, and scale (Stevens et al., 2021).In terms of legality, TU interventions can range from unsanctioned to sanctioned projects (Lydon et al., 2016). For instance, Community-led intersection improvement by a group of community residents is unsanctioned, while Paris's Pop-up Corona Cycleway, a network of pop-up bike lanes implemented during Covid-19 lockdowns, was a sanctioned project. (Buehler & Pucher, 2022; Moran, 2022). In general, TU projects often begin as unsanctioned grassroots initiatives, but can eventually become sanctioned interventions (Lydon et al., 2015, 2016).

In terms of duration, TU interventions are typically temporary, lasting from a few hours to days, months, or even a few years (Urban System, 2020). However, it is possible for temporary interventions to transition into permanent projects (Lydon et al., 2016). For example, a two-hour project at a parking lot in central San Francisco featuring a bench, some grass, and a tree initiated by grassroots activists transitioned

into the annual global event Park(ing) Day, celebrated in cities around the world (Littke, 2016). In terms of scale, TU interventions can range from city-scale interventions, such as Paris Plages,[1] Mexico City's Paseo de la Reforma,[2] and Times Square[3] in New York, to small-scale tactical interventions at the neighbourhood level, such as Derbyshire Pocket Park and Van Gogh Wal in London, and New York City's Plaza Program (Gehl Studio NY & Max Bond Center, 2015; Moser et al., 2020).

In general, Tactical urbanism is a method for redefining the image, function, and role of public spaces by repurposing them to bring about positive change in communities (da Cruz MOSCARELLI, 2020). It can address issues such as local resilience, equity, safety, community development, and infrastructure gaps (Stevens & Dovey, 2022; Urban System, 2020).

2.2 Tactical Urbanism During Covid-19 Pandemic

The COVID-19 pandemic has highlighted a number of critical issues in urban areas, including public health, transportation, pollution, food access, and more. Urban areas have been particularly affected by the pandemic due to their high population density and the complexity of human interactions (Smart Growth America, 2022a, 2022b). This has led to a range of negative impacts, including increased air pollution, limited access to healthcare, and high rates of chronic illnesses (UN-Habitat, 2021). In addition, underserved urban communities with vulnerable populations, such as those experiencing poverty or pre-existing inequalities, have been disproportionately affected by the pandemic (Smart Growth America, 2022b).

The pandemic has also taught us many lessons, including the importance of *lighter, quicker, and cheaper* actions in streets and neighbourhoods to slow the spread of COVID-19. These actions include allocating public open spaces for social distancing and outdoor activities. Since the outbreak in March 2020, the TU (Temporary Use) approach has gained popularity as a local resiliency tool. It has been used by a variety of groups, including concerned community residents, advocacy non-profits, artists, city leaders, policymakers, and practitioners, to test new ideas, engage the community, gather feedback, and build trust. The successful handling of the pandemic can also impact the way we tackle other urban complex problems, such as climate change, economic development, and pollution control, at the local level (Gehl, 2021; ITDP, 2020; Smart Growth America, 2022b).

Covid-19 pandemic and its associated barriers have changed the relationship between people, places, and public service delivery in cities and provided new possibilities for people to use public spaces in a new and innovative way like play streets,

[1] . The seasonal artificial beaches along the Seine.

[2] . Pop-up bike lanes.

[3] . Pedestrian plaza.

parklets, pop-up bike lanes (Herman & Drozda, 2021; NACTO, 2020; Urban System, 2020).

TU, with creative, low-cost, temporary, and easily implemented actions played a critical role in helping communities face the pandemic challenges in a more human-centric manner and with a vision for long-term change (Gehl, 2021; Graziano, 2021). There are various examples of using TU approach during Covid-19 pandemic, including both citizen-led and city-led interventions, as well as sanctioned and unsanctioned practices—Like temporary pop-up bike lanes starting in cities such as New York, London, Berlin, and Paris by city leaders as a cheap, simple, and short-term solution intended for more safety and space for cyclists during the Covid-19. Or unsanctioned community gardening as a *guerrilla project*, mostly at neighbourhood scale intended for food resiliency and safe social interaction during the pandemic.

TU actions implemented in response to the challenges posed by Covid-19 lock-downs have been shown to have multiple benefits, including improving public health and safety (see Kraus & Koch, 2021; Smart Growth America, 2022a), promoting equity (see Burrowes & Schilling, 2021; NACTO, 2021; Smart Growth America, 2022b), and fostering diversity and resiliency (Burrowes & Schilling, 2021; Herman & Drozda, 2021). These actions have also been beneficial for local businesses. The evidence suggests TU interventions such as Slow Streets can have a positive economic impact during the COVID-19 pandemic, encouraging outdoor activity and boosting business for local shops and restaurants (Bliss, 2021; NACTO, 2021; Wilson, 2020b).

Despite TU's popularity during the pandemic, it has faced criticism for worsening spatial inequalities– there are arguments that TU actions emphasized "specific set of urban uses and users" while leaving basic needs and services unmet elsewhere (Bliss, 2021). Concerns have been raised about its potential for under-represented voices and perspectives supported in the design and implementation of TU projects—that the quick-build nature of these interventions often don't allow for enough community engagement before they are implemented, which can lead to designs that don't adequately meet the needs of the community (Gehl, 2021; NACTO, 2020, 2021; Wilson, 2020a, 2020b). The opponents also highlighted the case of low-quality interventions and regulatory barriers for specific groups such as BIPOC, and low-income communities (Schmidt, 2022). Additionally, there are concerns that institutional control may hinder innovation and community participation, such as when street closures are implemented without consulting non-white communities that may be disproportionately impacted (Graziano, 2021; Kim, 2022). Or, in the case of city-led TU, there are concerns about a lack of community buy-in due to the perception that their feedback has not been sufficiently considered (NACTO, 2021). Some scholars also view TU as a neoliberal withdrawal of government investment in underserved communities (Graziano, 2021; Stevens et al., 2021).

3 Some Examples of Tactical Urbanism that Arise in Response to Covid-19 Pandemic in Public Open Spaces

To address the challenges posed by Covid-19 in public open spaces, TU interventions were implemented in various small and large cities around the world, from the global south (e.g., Bogotá & Medellín, Colombia; São Paulo & Belo Horizonte, Brazil; Jakarta, Indonesia; Chennai & Ranchi, India) to the global north (e.g., San Francisco in United States, Paris, London, Milan, Berlin, Barcelona in Europe), in both affluent and poor, small or large cities. These actions also took many different forms (Kim, 2022). Table 1 lists some of the most common tactical urbanism interventions that were implemented in United States during the Covid-19 pandemic.

It is important to mention that even before the current pandemic, TU had already gained attention in the United States due to trends such as rapid urbanization, the Great Recession, the rise of Internet and social media, and the growing disconnect between government and citizens (Lydon et al., 2015, p. 63). The COVID-19 pandemic has just highlighted the need for innovative approaches to building social capital and organizational capacity among various stakeholders in the management of urban spaces (Stevens et al., 2021).

Thus, TU interventions during the Covid-19 pandemic can generally be divided into two categories: citizen-led, unsanctioned actions and city-led, sanctioned programs (Gehl, 2021; NACTO, 2021). Many local governments have created quick-build interventions to support individuals and communities, improve public health and community resilience (Gehl, 2021; Kim, 2022). At the same time, community members, community-based organizations, and grassroots groups also have taken innovative, unsanctioned action to meet the needs of people in streets and neighbourhoods (Graziano, 2021).

Examples of city-led interventions include the collaborative efforts of local authorities, such as municipalities and transportation departments, with the private sector and advocacy non-profits to creatively repurpose local streets and create temporary public open spaces (Graziano, 2021). These efforts encouraged both physical activity and social distancing through multi-stakeholder participation interventions (Kim, 2022; Pond-Danchik et al., 2020; Stevens et al., 2021). And they resulted in various types of TU projects, including but not limited to *Pop-up Safe and Healthy Streets, Shared Street, Curb Extensions, Placemaking & Beautification* (Herman & Drozda, 2021).

Table 1 lists city-led projects aimed to improve public health, encourage active transportation, and support local businesses by temporarily transforming street lanes, curb parking, sidewalks, and entire streets into other uses such as pop-up bike lanes, expanded outdoor patios, pop-up parklets and offering additional services like COVID-19 testing kiosks, health information centres, and youth programming (Vega-Barachowitz et al., 2020). These initiatives were implemented using temporary barricades like orange barrels, traffic cones, posters, and signs (Kim, 2022, p. 2).

To provide a few examples, I can point to Boston's *Healthy Streets* program, which involved the expansion of sidewalks and the installation of pop-up bike lanes,

Table 1 Some of the most prevalent tactical urbanism actions during Covid-19 in North America

TU project types	Brief description
Pop-up safe and healthy streets: Play streets, stay healthy streets	• To provide residents with temporary public spaces during the pandemic, some areas closed off streets or blocks to traffic and repurposed the public right-of-way for activities that promoted health and social interaction. These activities could include neighbourhood school activities, car-free celebrations, or simply providing more space for biking, walking, and rolling
Covid-19 real-life examples: – Healthy streets: e.g., Seattle, WA; Minneapolis, MN; Austin, TX, Atlanta, GA; Durham, NC; Boston, MA; New York City, NY – Play streets: e.g., New York City & Albany, NY; Los Angeles, CA – Streets for learning: e.g., Detroit, MI; Alexandria, VA	
Shared streets: Open streets, DIY open streets, open curbs, slow streets, complete streets	• To temporarily restrict motor vehicle access to residents and share street space by all modes (i.e., Pop-up protected bicycle lanes, Pedestrian lanes, Floating bus stops)
Covid-19 real-life examples: – Open streets: e.g., Denver, CO; Louisville, KY; New Orleans, LA; Austin, TX; Atlanta, GA; New York, NY; Philadelphia, PA; Miami Beach, FL – Open curbs: e.g., Des Moines, IA; Kansas City, MO; Brookline, MA; Kitchener, ON; Austin, TX – Slow streets: e.g., Oakland, Los Angele & San Francisco, CA; Seattle, WA; Portland, OR; Denver, CO; Norfolk, VA; Pittsburgh, PA; Chicago, IL; Detroit, MI; Baltimore, MD	
Curb extensions: Improving signage, Intersection Repair	• To enhance an existing crosswalks/ intersection with the intent of improving visibility, reducing vehicle speed, and improving accessibility for those with limited mobility
Covid-19 real-life examples: – Painting the crosswalk: e.g., Wenatchee, WA; Intersection Mural in Chattanooga, TN; Minneapolis, MN – Slow Streets Essential Places: e.g., Oakland, CA – Signal Recall: e.g., Asheville, NC; Charleston, SC; San Jose, CA; Miami Beach, FL	

(continued)

Table 1 (continued)

TU project types	Brief description
Placemaking and programming: Street for Dinning, Guerrilla Gardening, Pavement to Plazas, Pavement to Parks/ Parklets, Pop-Up Cafes, Chair Bombing, Food Carts/Trucks	• To employ painting, art, and other activation elements and programming that promote liveable streets and neighbourhood vitality

Covid-19 real-life examples

– Street for Dinning: e.g., NYC Open Restaurants program; Philadelphia dinning program; cafÃ© and retail zone in Tampa, FL; Streatery programs in Charlotte, NC & Norfolk, VA; Mom and Pop Parklet Program in Long Beach, CA; Patio Expansion program in Denver, CO
– Pop-up Plaza: e.g., SoHo, NY; Rockaways in New York City, NY; Richmond, VA; Fort Collins, CO; Washington, D
– Pop-up retail: e.g., Mobile vendors in Madison, WI
– Pop-up street events: e.g., public art events in Charlotte; Neighbourhood Spots events in Norfolk, VA
– Chair bombing in Queens, NY

Note Adapted from https://street-plans.com; https://nacto.org; https://smartgrowthamerica.org; https://knightfoundation.org; https://www.streetlab.org; https://www.covidmobilityworks.org; https://playingout.net/play-streets/

and Minneapolis' implementation of 16 miles of Stay Healthy Streets (NACTO, 2021; Sharma, 2021). Other cities, such as Oakland, Vancouver, and Detroit, have implemented traffic calming measures at the neighbourhood level, closed certain areas to vehicle traffic, and developed programs such as *Streets for People*. Or, through the NACTO's Streets for Pandemic Response and Recovery program, cities such as Denver, Long Beach, Philadelphia, and Portland have implemented Open Streets and other temporary lane reallocation programs to support non-white and low-income business owners by facilitating outdoor dining, shopping, and commerce (NACTO, 2021; Vega-Barachowitz et al., 2020).

It is crucial to consider that the success of these programs can often be traced back to the input and advocacy of local groups, including community residents, advocacy non-profits, businesses, artists, city leaders, policymakers, and practitioners (Pond-Danchik et al., 2020). For example, in New York City, the implementation of the Open Streets and outdoor dining space initiatives can be traced back to the input and advocacy of groups like development community organizations, the NYC Dept. of Transportation, and local Business Improvement Districts (Smart Growth America, 2022b). Additionally, the Slow Streets program in Oakland was updated based on feedback from residents during the pilot phase. As a result, the Slow Streets Essential Places program was added, which provides temporary traffic safety improvements at pedestrian crossings (Pond-Danchik et al., 2020).

In addition to city-led TU programs, citizen-led actions have emerged as a prominent solution for improving the quality of life in cities in a low-budget way during the Covid-19 pandemic (Herman & Drozda, 2021; Majewska et al., 2022). These actions

often involve temporarily repurposing streets and unused spaces by groups of citizens, such as community residents and grassroots organizations, who are seeking to improve their communities and advocate for changes to local policies. These actions took many different forms, including creating pop-up plazas, DIY open streets, pop-up bike lanes, chair bombing, organizing community clean-up efforts, and creating temporary community gardens. Citizen-led TU actions during the Covid-19 pandemic have several benefits such as, enhancing community resilience, and asserting citizens' rights, developing sense of belonging and place identity (Gehl, 2021; Stevens et al., 2021).

The most important characteristic of TU approach during the Covid-19 pandemic is that it did not recommend fixed and one-size-fits-all solutions but deliberate agile, flexible, and temporary responses. This approach insists on the rights of individuals in shaping their communities (Fabian & Samson, 2016; Kim, 2022).

4 The Enabling and Innovative Role of Tactical Urbanism in Urban Governance

By reviewing the TU interventions in United States during the COVID-19 pandemic, we can identify the key factors that contribute to the effectiveness of TU as a tool for urban governance. This perspective allows us to understand the potential and usefulness of TU as a practical and innovative solution at the local level for addressing urban governance challenges.

4.1 Tactical Urbanism as a Real-Life Setting Lab

Living Labs (LLs) are collaborative research and development environments that simulate real-world conditions to test and evaluate new technologies, products, and services (Fuglsang et al., 2021). Urban Living Labs, in particular, bring diverse stakeholders together to co-create and co-innovate solutions in real-life environments to produce sustainable impact (Fuglsang et al., 2021; Gascó, 2017; Hansen et al., 2021). LLs are commonly used in urban governance, particularly in the European Union, to mobilize residents to address ecological transition-related uncertainties and complexities (Wachter, 2021). They facilitate collaboration among stakeholders such as community residents, local government, innovative developers, non-profit organizations, and universities to co-create policies, services, and goods that meet local demand (Rizzo et al., 2021).

Drawing on the main characteristics of LLs and looking at examples of TU interventions related to Covid-19, it becomes clear that the TU approach have many similarities to the concept of LLs and can be considered as an innovative urban governance tool. Both approaches prioritize the transformation of public spaces through

innovation, incrementalism, experimentation, learning-by-doing, as well as active citizen engagement (Andres, 2021; Rizzo et al., 2021). This focus on shared value creation and the improvement of the built environment for individuals and communities aligns with the needs of users or community residents (Stevens & Dovey, 2022; Stevens et al., 2021; Wachter, 2021).

Based on the concept of LLs, TU can serve as a *laboratory for experimentation* for various urban governance stakeholders, particularly community residents. In this laboratory, stakeholders can redefine the image, function, and role of public spaces through the implementation of lighter, quicker, and cheaper actions in real-life settings (Lydon et al., 2015, 2016). The hybrid, experiential, intentional, and flexible nature of both LLs and TU enables the encouragement of new institutional arrangements and innovative cooperation to improve the public realm and tackle various goals, including local resiliency, equity concerns, safety issues, and infrastructure gaps (Gascó, 2017; Scholl & Kemp, 2016; Wachter, 2021).

LLs and TU involve acquiring first-hand knowledge and experience through a process of learning and doing (Wachter, 2021). This experimentation aspect of LLs and TU brings us closer to the ideal of direct democracy by incorporating the voices of community residents and leading to the generation of shared knowledge (von Wirth et al., 2019). This process can advocate for a shift in governance towards a *new mode* based on deliberation and negotiation between various actors to reach agreements (Hansen et al., 2021; Scholl & Kemp, 2016).

4.2 Tactical Urbanism as a Co-creation Platform

The other rationale for considering TU as an innovative governance tool relates to its collaborative and experimental nature in co-creating public open spaces (NACTO, 2021). A fundamental aspect of all TU interventions for activating public open spaces during the Covid-19 is the platform that enables collective experimentation (i.e., co-experience), not only through tangible actions (i.e., co-design) but also through a cognitive process that generates shared knowledge, social relations, and public values t (i.e., co-create) (Sorrentino et al., 2018; Stevens et al., 2021; Strokosch & Osborne, 2020).

One key aspect of TU in public spaces is about the involvement of community members in the co-creation process. TU is being recognized not just for the outcome, but also for the process involved. TU has the potential to invite relevant and affected actors and lower the transaction costs of collaborating and supporting innovation (Burrowes & Schilling, 2021; Wilson, 2020a). In various cases, community-based organizations and civil society groups have played a leading role in the design and implementation of TU interventions, working closely with local government officials (i.e., such as municipalities, health authorities, transportation departments, and school communities) and other stakeholders to identify and address the most pressing needs of their communities (Stevens & Dovey, 2022; Stevens et al., 2021).

The pandemic has emphasized the need for multi-stakeholder participation, as cities worldwide have had to adapt quickly to the challenges posed by the pandemic. And as a result, this low-cost, temporary, and bottom-up approach has provided a platform where various stakeholders can come together to ensure that the interventions are responsive to the specific challenges and opportunities facing multiple actors (Ansell & Torfing, 2021).

Another critical aspect of TU as the co-creation platform is its focus on experimentation and temporariness in public open spaces (Cariello et al., 2021). TU interventions have often been implemented on a small scale and a temporary basis, allowing for rapid testing and iteration of ideas. This has allowed for the rapid deployment of solutions to address urgent needs, such as creating pop-up outdoor dining spaces for restaurants or reallocating street space for pedestrians and cyclists. At the same time, the temporary nature of these interventions has allowed for flexibility and adaptability in response to changing conditions, such as the need to adapt to new public health guidelines or the emergence of new challenges and opportunities (Gehl, 2021).

A third key aspect of TU interventions related to co-creation in the context of Covid-19 has been the emphasis on inclusivity and equity in activating public open spaces. Many cases of TU interventions have been initiated or updated to address the specific needs and challenges facing marginalized communities, such as BIPOC, and low-income communities (Gehl, 2021; NACTO, 2021). Involving community members in the design and implementation process increases the chance that all community members share the TU project's benefits and the result be equitable and inclusive for various actors (Burrowes & Schilling, 2021; Dadashpoor & Alvandipour, 2020).

4.3 Tactical Urbanism as an Active-User Involvement

The aim of TU approach is to empower individuals and communities to take an active role in shaping public open spaces and designing solutions to challenges faced by those who use public spaces. By prioritizing the wants needs of the community (i.e., underserved voices) over predetermined solutions, it is possible to create innovative and practical solutions that are better able to address the complexities of people's lives and are more preventative and resilient (Cariello et al., 2021; Gehl, 2021). This approach to public space transformation focuses on involving the community in the co-creation process to develop solutions that are responsive to their needs, fostering a sense of ownership and agency among citizens exercising their right to the city (Burrowes & Schilling, 2021).

TU emphasizes the active involvement of residents and other stakeholders in the co-creation of public spaces (Graziano, 2021). Actually, the quick-build nature of TU allows residents to do experiments and to have a say in the design of their neighbourhood (Graziano, 2021). This can be especially important for communities of colour, which have often been disproportionately impacted by traditional planning processes (Wilson, 2020a). This may involve various forms of public engagement for reaching

to community members such as door knocking and conversations, community meetings, focus groups, workshops, online forums, public art installations, pop-up events, and crowdsourcing. By involving residents in the planning and implementation of interventions, cities can create solutions that are tailored to the needs of the community and have their support (Gehl, 2021). The active participation of residents is crucial for creating solutions that are responsive to the community and endorsed by them. It also can be an effective tool for promoting equity in urban communities and helping to address systemic problems that disproportionately impact marginalized groups (Bryer & Alvandipour, 2021; Gehl, 2021; Graziano, 2021).

Citizen engagement in short-term, low-cost, and scalable solutions to real-life issues can be highly beneficial for a number of reasons. Firstly, such participation is a clear demonstration of direct democracy in action to communicate the desire and possibility for change (Graziano, 2021). This can help to create more equitable and inclusive cities. Second, it can also help to foster a sense of empowerment and ownership among residents and thus generating support and momentum for the projects (Cariello et al., 2021). Thirdly, engaging with the community can also help to identify potential challenges and obstacles, facilitating the building of consensus and cooperation among different stakeholders.

4.4 Tactical Urbanism as a Frugal Innovation

TU can be seen as *self-help* activism to the transformation of public spaces and share traits with disruptive innovation. TU can be considered a type of frugal innovation. *Frugal innovation* is a process of creating solutions that are simple, low-cost, and effective, and that address the needs of underserved or marginalized communities. This approach is often necessary in contexts where resources are limited, such as in developing countries or in communities facing economic challenges (Prabhu, 2017).

TU fits within this framework because it involves the use of low-cost and temporary interventions to improve the quality of urban life (Cariello et al., 2021). These interventions are often designed and implemented in a way that is simple and cost-effective, and that addresses the immediate needs of residents (Gehl, 2021). During the pandemic we have seen examples of feasible TU interventions include creating DIY parklets and outdoor dining areas using simple materials such as planters, tables, and chairs, and leveraging underutilized or underdeveloped public spaces, such as vacant lots or empty buildings, as temporary gathering places that support public health, mobility, and local businesses (Bertolini, 2020).

Overall, TU can be considered a form of frugal innovation because it involves the use of simple short-term, and low-cost interventions to address the immediate needs of urban communities. This approach can be particularly effective in contexts where resources are limited, and it can help to create more sustainable and liveable cities (Burrowes & Schilling, 2021; NACTO, 2021; Smart Growth America, 2022b).

5 Concluding Remarks and Implications

The COVID-19 pandemic has shown that the TU approach, with its low-cost, temporary, and easily implemented actions, as well as its vision for long-term interventions, can be a valuable governance tool for improving the quality of life in cities under uncertainty. This approach can raise awareness around community needs and issues, ensure that public space interventions are responsive to the needs of the community and can support the development of more resilient and equitable cities. The way unsanctioned innovations led to sanctioned practices, during the pandemic, demonstrates the potential of allowing bottom-up initiatives to inform the direction of top-down processes.

Many TU actions were initially implemented as temporary responses to the pandemic but have since become permanent solutions. Even those that have not become permanent retain their advantages, with the pandemic acting as a catalyst and giving a new face to the TU movement. For example, the pop-up Slow Street movement, which began as a temporary response to COVID-19 disruption in transportation behaviours, has been adopted by many cities as a policy solution for creating more space for physically distanced outdoor activity and promoting pedestrian safety. Similarly, the creation of parklets and temporary gardens has been embraced by many cities as a way to enhance the public realm and provide new amenities for residents.

TU provides a flexible and adaptable approach for addressing complex challenges, particularly in underserved communities. Its emphasis on experimentation and iteration enables cities to identify effective and sustainable solutions quickly and efficiently. TU also encourages collaboration and participation from the local community, leveraging their collective knowledge and resources for more inclusive decision-making. In addition, TU can promote a culture of innovation and creativity, inspiring residents, and stakeholders to generate new ideas and approaches to address urban challenges.

The present research offers insights into the field of urban governance, local government leadership and management presenting a novel perspective on how to approach the complex challenges facing cities, with a particular focus on the role of public open spaces. Practitioners and academics can use this research to systematically consider the essential elements of transferring resources and power to communities, navigating challenges, and sustaining thriving communities. However, further research is necessary to fully understand the potential and limitations of TU. It would be interesting to examine how TU initiatives may differ in character during normal times, and how the lessons learned, and experiences gained during the pandemic may influence the direction and focus of future TU initiatives. Additionally, there are various motivations for TU initiatives beyond the pandemic, such as social justice, environmental sustainability, and community development. It will be important to consider how these motivations shape TU initiatives and how they may intersect with pandemic-related concerns. It is essential to recognize that TU should be viewed as a supplementary tool in urban governance toolbox. So, more work is needed to understand how TU can be integrated into broader top-down policy making efforts

to achieve long-term, sustainable outcomes in post pandemic era. Finally, future studies should focus on developing more effective methods for evaluating the effectiveness of these interventions, as well as exploring new ways to engage underserved communities.

References

Andres, L. (2021). The importance of temporary urbanism in deconstructing cities and shaping the post-pandemic city research agenda. *The Large Glass.*

Ansell, C., & Torfing, J. (2021). Co-creation: The new kid on the block in public governance. *Policy and Politics, 49*(2), 211–230. https://doi.org/10.1332/030557321X16115951196045

Bertolini, L. (2020). From "streets for traffic" to "streets for people": Can street experiments transform urban mobility? *Transport Reviews, 40*(6), 734–753. https://doi.org/10.1080/01441647.2020.1761907

Bike Curious, S. F. (2017, March 13). The history of Tactical Urbanism: DIY street enhancements prompting permanent safe streets. https://www.bikecurioussf.com/single-post/2017/03/13/the-history-of-tactical-urbanism-diy-streetenhancements-prompting-permanent-safe-streets

Bliss, L. (2021, May 11). *Where covid's car-free streets boosted business.* Bloomberg.

Bryer, T. A., & Alvandipour, N. (2021). *Public administration and citizen participation: From isolation to activism to skepticism.* Edward Elgar Publishing. https://doi.org/10.4337/9781789908251.00011

Buehler, R., & Pucher, J. (2022). Cycling through the COVID-19 pandemic to a more sustainable transport future: evidence from case studies of 14 large bicycle-friendly cities in Europe and North America. *Sustainability, 14*(12), 7293. https://doi.org/10.3390/su14127293

Burrowes, K., & Schilling, J. (2021). *From streets to citizen spaces: Positioning parks and green spaces in an equitable COVID-19 recovery.*

Cariello, A., Ferorelli, R., & Rotondo, F. (2021). Tactical urbanism in Italy: from grassroots to institutional tool—Assessing value of public space experiments. *Sustainability, 13*(20), 11482. https://doi.org/10.3390/su132011482

da Cruz MOSCARELLI, F. (2020). Using placemaking methodologies to transform degraded public spaces into places. *Space and Culture.* https://doi.org/10.1177/1206331220911360.

Fabian, L., & Samson, K. (2016). Claiming participation—A comparative analysis of DIY urbanism in Denmark. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, *9*(2), 166–184. https://doi.org/10.1080/17549175.2015.1056207.

Dadashpoor, H., & Alvandipour, N. (2020). A genealogy of the five schools of justice in planning thought. *Habitat International, 101*, 102189. https://doi.org/10.1016/j.habitatint.2020.102189.

Fuglsang, L., Hansen, A. V., Mergel, I., & Røhnebæk, M. T. (2021). Living labs for public sector innovation: An integrative literature review. *Administrative Sciences, 11*(2), 58. https://doi.org/10.3390/admsci11020058

Gascó, M. (2017). Living labs: Implementing open innovation in the public sector. *Government Information Quarterly, 34*(1), 90–98. https://doi.org/10.1016/j.giq.2016.09.003

Gehl. (2021). *Adaptive public space: Places for people in the pandemic and beyond.*

Gehl Studio NY, & Max Bond Center. (2015). *Public Life & Urban Justice in NYC's Plazas.*

Graziano, T. (2021). Smart technologies, back-to-the-village rhetoric, and tactical urbanism. *International Journal of E-Planning Research, 10*(2), 80–93. https://doi.org/10.4018/IJEPR.20210401.oa7

Guterres, A. (2020). *Policy brief: COVID-19 in an urban world.*

Hansen, A. V., Fuglsang, L., Liefooghe, C., Rubalcaba, L., Gago, D., Mergel, I., Haug, N., Taivalsaari Røhnebæk, M., & Mureddu, F. (2021). Living labs for public sector innovation: Insights from a

European case study. *Technology Innovation Management Review*, *11*(9/10), 47–58. https://doi.org/10.22215/timreview/1464

Herman, K., & Drozda, Ł. (2021). Green infrastructure in the time of social distancing: Urban policy and the tactical pandemic urbanism. *Sustainability, 13*(4), 1632. https://doi.org/10.3390/su13041632

Herman, K., & Rodgers, M. (2020). From tactical urbanism action to institutionalised urban planning and educational tool: The evolution of park(ing) day. *Land, 9*(7), 217. https://doi.org/10.3390/land9070217

ITDP. (2020). *How to scale tactical urbanism using lessons from the global south: From pilot to permanent.*

Kim, J. (2022). COVID-19's impact on local planning and urban design practice: Focusing on tactical urbanism and the public realm with respect to low-income communities. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 1–7.https://doi.org/10.1080/17549175.2022.2146155.

Kraus, S., & Koch, N. (2021). Provisional COVID-19 infrastructure induces large, rapid increases in cycling. *Proceedings of the National Academy of Sciences*, *118*(15). https://doi.org/10.1073/pnas.2024399118

Littke, H. (2016). Revisiting the San Francisco parklets problematizing publicness, parks, and transferability. *Urban Forestry & Urban Greening, 15*, 165–173. https://doi.org/10.1016/j.ufug.2015.12.010

Lydon, M., Garcia, A., & Duany, A. (2015). *Tactical urbanism: Short-term action for long-term change*. Island Press. https://books.google.com/books?id=MaJ0BgAAQBAJ.

Lydon, M., Garcia, T., Flynn, J., Murriente, S., Wall, D., & Simpson, C. (2016). *Tactical urbanist's guide to materials and design.* The Street Plans Collaborative. http://tacticalurbanismguide.com/guides/tactical-urbanists-guide-to-materials-and-design/.

Majewska, A., Denis, M., Jarecka-Bidzińska, E., Jaroszewicz, J., & Krupowicz, W. (2022). Pandemic resilient cities: Possibilities of repairing Polish towns and cities during COVID-19 pandemic. *Land Use Policy, 113*, 105904. https://doi.org/10.1016/j.landusepol.2021.105904

Moran, M. E. (2022). Treating COVID with bike lanes: design, spatial, and network analysis of 'pop-up' bike lanes in Paris. *Findings*. https://doi.org/10.32866/001c.33765.

Moser, B., Malzieu, T., & Petkova, P. (2020, May 14). *Tactical urbanism: Reimagining our cities post-Covid-19*. Foster + Partners.

NACTO. (2020). *Streets for pandemic response & recovery.*

NACTO. (2021). *Streets for pandemic response & recovery: Grant program*

Pond-Danchik, N., Wier, M., & Patton, J. (2020). *Oakland slow streets interim findings report*.

Prabhu, J. (2017). Frugal innovation: Doing more with less for more. *Philosophical Transactions of the Royal Society a: Mathematical, Physical and Engineering Sciences, 375*(2095), 20160372. https://doi.org/10.1098/rsta.2016.0372

Rizzo, A., Habibipour, A., & Ståhlbröst, A. (2021). Transformative thinking and urban living labs in planning practice: A critical review and ongoing case studies in Europe. *European Planning Studies, 29*(10), 1739–1757. https://doi.org/10.1080/09654313.2021.1911955

Schmidt, S. (2022, January 3). *What the pandemic's 'open streets' really revealed*. Bloomberg.

Scholl, C., & Kemp, R. (2016). City labs as vehicles for innovation in urban planning processes. *Urban Planning*, *1*(4), 89–102. https://doi.org/10.17645/up.v1i4.749

Sharma, M. (2021). *Impact of Covid-19 on city streets* [Honors scholar theses]. University of Connecticut.

Sheppard, S. (2022, November 22). *Toronto's Curbside patios made 49 times more money than the parking they replaced*. Strong Towns.

Smart Growth America. (2022a). *Safety demonstration projects.*

Sorrentino, M., Sicilia, M., & Howlett, M. (2018). Understanding co-production as a new public governance tool. *Policy and Society, 37*(3), 277–293. https://doi.org/10.1080/14494035.2018.1521676

Smart Growth America. (2022b). *Shared spaces and health equity: Lessons from a pandemic.*

Stevens, Q., Awepuga, F., & Dovey, K. (2021). Temporary and tactical urbanism in Australia: perspectives from practice. *Urban Policy and Research, 39*(3), 262–275. https://doi.org/10.1080/08111146.2021.1963225

Stevens, Q., & Dovey, K. (2022). Temporary and tactical urbanism. *Routledge*. https://doi.org/10.4324/9781003284390

Strokosch, K., & Osborne, S. P. (2020). Co-experience, co-production and co-governance: An ecosystem approach to the analysis of value creation. *Policy and Politics, 48*(3), 425–442. https://doi.org/10.1332/030557320X15857337955214

UN-Habitat. (2021). *Cities and pandemics: Towards a more just, green and healthy future*.

Urban System. (2020). *Tactical urbanism toolkit: A guide to demonstration and interim projects focused on active transportation and placemaking*.

Vega-Barachowitz, D., Flynn, M., & Farhi, L. (2020, December 22). *The post-pandemic street: From designing streets to designing process.* Planetizen.

von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., & Coenen, L. (2019). Impacts of urban living labs on sustainability transitions: Mechanisms and strategies for systemic change through experimentation. *European Planning Studies, 27*(2), 229–257. https://doi.org/10.1080/09654313.2018.1504895

Wachter, S. (2021). Governing with Urban La. *HAL*.

Wilson, K. (2020a, June 6). *Can tactical urbanism be a tool for equity? a conversation with mike Lydon and tony Garcia.* Street Blog, USA.

Wilson, K. (2020b, September 3). *Ten cities to use open streets as tools for equity and COVID-resilience.* Street Blog, USA.

Chapter 6
Urban Parks and Mental Health Recovery During the Pandemic: Insights from an Iranian Case Study

Mehdi Nilipour and Ali Cheshmehzangi

Abstract As a result of the COVID-19 pandemic, urban parks have been highlighted as necessary for cities to cope with the stress of the virus threat and the physical restrictions imposed in response. Public health and urban planning can benefit from examining the associations between urban parks and mental health. The present study aimed to investigate the relationship between Fateh Garden and the mental health of its users. It is vital for public health and urban planning to take into account the associations between parks and mental health. Fateh Garden is the second largest park in Karaj, with an area of 15 ha. This study employed a modified Warwick-Edinburgh Mental Well-being Scale (WEMWBS) to measure the impact of Fateh Garden on users' mental health. Seventy-six of the users filled out the questionnaire. Furthermore, fifty-seven semi-structured interviews composed of 27 males and 30 females were conducted with Fateh Garden users. Participants were asked to rate fourteen items on a 1–5 Likert scale about their mental health. The mean score in this study is 52.12, which is higher than the mean score norms for WEMWBS and shows the high impact of Fateh Garden in improving the mental health of its users. The results also indicated that positive mental health was significantly and positively correlated with Fateh Garden's users' age, marital status, and employment status. This study confirmed a generally beneficial relationship between Fateh Garden and the mental health of its users, especially during the pandemic. Moreover, the present study shows that people choose a park that reminds them of their favorite components and gives them peace of mind.

Keywords Urban parks · Mental health · Pandemic · Iranian park · Fateh Garden

M. Nilipour (✉)
Department of Urban Planning, University of Larestan, Lar, Iran
e-mail: m.nilipour@tabriziau.ac.ir; m.nilipour@lar.ac.ir

A. Cheshmehzangi
School of Architecture, Qingdao City University, Qingdao, China

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_6

1 Introduction

As a synonym for mental wellbeing, 'positive mental health' can be described as '*a state of wellbeing in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to contribute to his or her community*' (World Health Organization, 2018). Mental health is significantly affected by the ongoing COVID-19 pandemic. It is expected that the mental health impact of the pandemic will be long-lasting and wide-ranging, from the concerns about virus transmission and the psychological effects of lockdowns and self-isolation to the effects of financial worries, unemployment, and social exclusion (World Health Organization, 2021). There have been studies on the relationship between nature and mental health (e.g., Bratman et al., 2012; Douglas, 2012; Kaplan, 2001a, 2001b; Maller et al., 2006; Sullivan et al., 2004). However, parks in modern urban areas tend to be among the most accessible forms, and importantly for health equity, are usually provided and maintained for the public good (Wood et al., 2017). As a result of the COVID-19 pandemic, urban parks have been highlighted as important for cities to cope with the stress of the virus threat and physical restrictions imposed in response and also as alternative places for physical activities and social interactions (World Health Organization, 2021).

The importance of parks for mental and physical health has gained more attention in recent years (Callaghan et al., 2020). Urban parks can promote physical activities that are protective of mental health. Self-esteem is often boosted by physical activities, such as sports (Biddle, 2016). A limited, but significant body of research has demonstrated the benefits of parks on mental health (Wood et al., 2017; McEachan et al., 2018; Sarkar et al., 2018; Callaghan et al., 2020). Despite this, it is unclear how parks can contribute to mental health because there are relatively few published studies on the topic (Wood et al., 2017). To date, research has focused more on the psychological benefits of access to parks for physical activity than on parks as health outcomes (Wood et al., 2017). Mental health can be positively impacted by urban parks according to a number of theories (Callaghan et al., 2020).

It was proposed by Kaplan and Kaplan (1989) that urban parks provide psychological restoration to counter the mental fatigue of modern life in urban environments. People's desire for nature is referred to as biophilia; humans evolved in natural landscapes where green spaces would have provided shelter, food, and so on, so they may still feel positive in such environments (Houlden et al., 2017; Wilson, 2007). According to Attention Restoration Theory, everyday tasks require effortful and focused attention, while nature attracts an involuntary fascination that allows the brain to rest and regain concentration (Kaplan, 1984, 2001a, 2001b). Regarding Stress Recovery Theory, nature views help restore a relaxed emotional state in stressed individuals (Ulrich, 1986; Ulrich et al., 1991). Based on Antonovsky's theory (1996), positive mental health emphasizes health and well-being rather than diseases, which promotes a positive paradigm approach to health and wellbeing (Appelqvist-Schmidlechner et al., 2020). Houlden et al. (2017) examined whether green space

is associated with a multidimensional mental wellbeing measure, including eudaimonic and hedonic items. In their study, no statistically significant correlation was found between mental wellbeing and the amount of green space in the local areas.

Using a scoping review methodology, Callaghan et al. (2020) conducted an overview of the literature regarding urban parks and mental health. Based on the results of their work, there is a positive link between urban parks and mental health in the majority of studies, which indicates that increasing urban parks may have benefits for the health of the public in the long run. An interesting and novel study by Appelqvist-Schmidlechner et al. (2020) found a positive relationship between mental wellbeing and physical activity among young adult males, which is hard to reach in health surveys. Individuals with low levels of positive mental health may benefit from leisure time, according to the findings of this study.

Generally, there are positive associations between parks and mental health based on the small number of studies looking at mental health as a primary outcome (e.g., Annerstedt et al., 2012; Astell-Burt et al., 2014; Francis et al., 2012). Parks and mental health have been linked in the literature through several pathways; In addition to their restorative effects (Maller et al., 2006), parks are known to reduce stress (Ward Thompson et al., 2012) and facilitate social interaction and the development of social ties (Bedimo-Rung et al., 2005; Chiesura, 2004; Kuo et al., 1998; Wolch et al., 2014). This study's purpose was to investigate the relationship between Fateh Garden and the mental health of its users. The second goal of this research was to investigate the relationship between the age, gender, educational level, and marital and employment status of users with their mental health.

2 Urban Parks in Iran: A General Overview

The increasing population of cities, living in small apartments, the decline in household income, and the rising marriage age have made Iranian urban parks the main places for leisure, especially for young people and their friends (Bahriny & Bell, 2020). Urban parks, as popular places in Iran (Hami & Maruthaveeran, 2018) have been used for passive and individual active activities (Hami, 2009) and sports activities (Hami & Maruthaveeran, 2018). A noteworthy point is the significant presence of women in Iranian urban parks. Despite the government's mandatory dress code for women and other limitations restricting women's presence and activities in Iranian urban parks, they constitute half of the users of urban parks in Iran (Khakzand et al., 2015). According to what has been said (Hamzenejad & Gorji, 2018), urban parks in Iran are receiving more attention than before.

Arjmand (2017) believes that the construction of urban parks in Iran may be based on the idea of Persian gardens, or it may be formed from the western idea in the modernization process. He mentions that some scholars consider Persian gardens the Persian version of the modern park. As he asserts, Persian gardens have been integral to architecture and urban planning in Iran. Due to the lack of sufficient water

resources in Iran, several private gardens in Iranian cities have been turned into urban parks to compensate for the lack of urban parks (Rismanchian, 2009).

One of these gardens is Fateh Garden, located in Karaj. Until about ten years ago, it was used as a private garden full of many fruit trees that were sold commercially. Due to the convenient location of this garden in the city, its numerous and valuable trees, and the demand of the citizens of Karaj, the Municipality of Karaj took over this garden, and within a few years, with the addition of the necessary facilities, turned this garden into an urban park. The main aim of the study was to explore the role of Fateh Garden in the mental health recovery of users during the pandemic.

3 Methods

3.1 Measures

We employed a modified Warwick-Edinburgh Mental Well-being Scale (WEMWBS) to measure the impact of Fateh Garden on users' mental health. WEMWBS covers the majority of positive mental health concepts and contains positively worded items regarding different aspects (Tennant et al., 2007). At Fateh Garden, participants were asked to rate fourteen items on a 1–5 Likert scale about their mental health (thoughts and feelings). Among the items on this questionnaire are those that measure optimism, perceptions of usefulness, confidence, social interaction, energy, and interest in new activities. Scores were calculated by adding responses for each item answered (range: 14–70) (Wood et al., 2017). Higher scores indicate greater mental wellbeing based on the weighted sum score (Appelqvist-Schmidlechner et al., 2020). The permission to use the WEMWBS was received from Warwick Medical School.

A minimum of 50 participants are required as a rule of thumb in WEMWBS (Taggart et al., 2016). Therefore, seventy-six users were recruited for this study. Respondents were asked to rate the impact of Fateh Garden on their mental health from 1 (none of the time) to 5 (all of the time) on the following items: "Being in Fateh Garden helps me to feel optimistic about the future", "Being in Fateh Garden helps me to feel useful", "Being in Fateh Garden helps me to feel relaxed", "Being in Fateh Garden helps me to feel interested in other people", "Being in Fateh Garden helps me to have the energy to spare", "Being in Fateh Garden helps me to deal with problems well", "Being in Fateh Garden helps me to think clearly", "Being in Fateh Garden helps me to feel good about myself", "Being in Fateh Garden helps me to feel close to other people", "Being in Fateh Garden helps me to feel confident", "Being in Fateh Garden helps me to be able to make up my own mind about things", "Being in Fateh Garden helps me to feel loved", "Being in Fateh Garden helps me to feel interested in new things" and "Being in Fateh Garden helps me to feel cheerful". Moreover, fifty-seven semi-structured interviews composed of 27 males and 30 females were conducted with Fateh Garden users. Among those interviewed were 3 children (under 15 years of age), 14 adolescents (15–20 years old), 28 youths (20–35 years old), 9

middle-aged people (35–60 years old), and 3 elderly people (over 60 years old), and they were composed of 27 males (47.4%) and 30 females (52.6%) overall.

3.2 Exploring Fateh Garden

According to the 2016 census, the city of Karaj, located in Alborz Province, has a population of 1,592,492 people, the fourth most populous city in Iran (Statistical Center of Iran, 2018). According to the Head of Landscape and Green Space Organization of Karaj Municipality (2020), there are 243 parks in Karaj. Fateh Garden is the second largest park in Karaj, with an area of 15 ha. Before turning into an urban park in 2006, this place had been used as an orchard since 1963. Fateh Garden is also one of the registered national heritages of Iran as one of the gardens of Jahanshahr (The Ministry of Cultural Heritage, Tourism and Handicrafts, 2006).

We selected Fateh Garden because this park is at the top of Karaj urban parks in terms of the number of photos and comments on social media such as Instagram and online tools such as Google Maps. The location of Fateh Garden in Karaj facilitates the access of the residents of the adjacent areas to it. Moreover, many entrances to the park from the streets and alleys and the possibility of parking cars on the side of the street have made it easy for visitors to access this park. Figure 1 shows the location of Fateh Garden in Karaj.

4 Results and Discussion

Concerning the mean scores of SWEMWBS, positive mental health was associated with gender, age, marital and employment status, and educational level (Table 1). According to Table 1, 46% of the respondents were male, and 54% were female. Furthermore, 33% were married, and 67% were single. The highest frequency of their age was between 20 and 29 years, with 30% of the total. Moreover, regarding the educational level, people with bachelor's degrees accounted for the most significant number, with 31% of the total. As for the employment status, employed people were the largest, with 33% of the total.

The provisional population means score norms for WEMWBS across different socio-demographic groups is 50.7 with a 95% confidence interval of 50.3–51.1 (Stewart-Brown & Janmohamed, 2008). The mean score in this study is 52.12 (Table 2), which is higher than the mean score norms for WEMWBS and shows the high impact of Fateh Garden in improving the mental health of its users.

A Pearson's correlation analysis was conducted to determine whether positive mental health was correlated with the age, gender, educational level, marital and employment status of Fateh Garden's users. The results of the analysis indicated that positive mental health was significantly and positively correlated with the age, marital and employment status of Fateh Garden's users (Table 3). It seems that Fateh

Fig. 1 A picture of Fateh Garden (*Source* Photo taken by the authors)

Garden has been more effective in improving the mental health of elderly users. Moreover, married users have experienced higher mental health compared to single ones in Fateh Garden. Furthermore, the impact of Fateh Garden in improving the mental health of retired users has been more than that of working people and students.

Moreover, a Pearson's correlation analysis was conducted to determine whether fourteen items of positive mental health were correlated with the age, gender, educational level, marital and employment status of Fateh Garden's users (Table 4). The analysis results indicated that 'interest in new activities' was significantly and negatively correlated with the educational level of Fateh Garden's users. This means that users with lower education are more willing to do new activities. Furthermore, 'feeling loved' and 'having the energy to spare' were significantly and positively correlated with Fateh Garden's users' employment status and age. This means that users who are old and retired feel more loved and have more energy to spare. Moreover, 'making up my mind about things', 'feeling confident', and 'feeling interested in other people' were significantly and positively correlated with Fateh Garden's users' marital and employment status and age. This means that married, old, and retired users feel more confident and interested in other people and can make up their minds about things better. In addition, 'feeling close to other people' was significantly and

Table 1 The number of samples in different sociodemographic groups

Variable	n	Percent
Gender	76	100
Male	35	46
Female	41	54
Age	76	100
19 years or younger	16	21
20–29	23	30
30–39	11	14.5
40–49	6	8
50–59	9	12
60 years or older	11	14.5
Educational level	76	100
Comprehensive school	15	20
Secondary education	15	20
Associate degree	2	3
Bachelor's degree	24	31
Master's degree	19	25
Doctorate	1	1
Marital status	76	100
Married	25	33
Single	51	67
Employment status	76	100
Studying	29	38
Employment	36	47
Retirement	11	15

Table 2 Some descriptive statistics of the samples

N	76
Mean	52.12
Median	53.00
Mode	55
Std. deviation	11.634

Table 3 The correlations between the positive mental health and the age, marital, and employment status of Fateh Garden's users (n = 76)

	Age	Marital status	Employment status
Positive mental health	0.275*	0.330**	0.341**

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

positively correlated with gender, marital and employment status, and the age of Fateh Garden's users. This means that users who are male, married, old, and retired feel closer to other people (see Fig. 2).

Furthermore, 'feeling good about myself' was significantly and positively correlated with the employment status of Fateh Garden's users. This means that users who are retired feel better about themselves. Additionally, 'dealing with problems well' was significantly and positively correlated with Fateh Garden's users' marital and employment status. This means that users who are married and retired feel better about themselves. Finally, 'perceptions of usefulness' was significantly and positively correlated with the marital status of Fateh Garden's users. This means that users who are married feel more valuable.

The present study aimed to investigate the relationship between Fateh Garden and the mental health of its users. It is important for public health and urban planning to take into account the associations between parks and mental health. To make public park planning and policy more effective, research should go beyond describing the general benefits of parks to distilling the qualities that can have the greatest impact on individual well-being (Wood et al., 2017). Even though most urban parks are effective at improving mental health in urban environments, some indications suggest that they may differ depending on the target group and geographical location (World Health Organization, 2021). According to the results, Fateh Garden significantly improves its users' mental health. Furthermore, Fateh Garden's users had significantly higher levels of positive mental health when they were older, married, and retired. This result is partly consistent with previous studies (i.e., Annerstedt et al., 2012; Appelqvist-Schmidlechner et al., 2020; Astell-Burt et al., 2014; Callaghan et al., 2020; Francis et al., 2012).

On the other hand, what was mentioned more than anything in the interviews were the meanings that were enjoyable for the users and the associations of people, objects, times, activities, and events that reminded the users of their satisfaction. For many users, Fateh Garden feels like home: '*Fateh Garden gives me a sense of home and peace*' [Sahar, a 32-year-old woman]. The ideal place in Iranian culture is paradise, which people wish to achieve in another world. For some users, Fateh Garden is reminiscent of paradise: '*Fateh Garden is always beautiful, but in spring, it is paradise*' [Ahmed, a 21-year-old man]. The main feature of paradise is beauty as one of the environmental features. This beauty doubles in some seasons, such as spring and autumn, due to the color of the trees.

However, the most important keyword in describing Fateh Garden by users is 'peaceful'. In this regard, the presence of tall and beautiful trees that give a special beauty to Fateh Garden in the four seasons of the year plays a decisive role. This garden also allows people to forget the problems of their lives and experience tranquility, even for a few hours: '*Fateh Garden has a special sense of calm and makes you take a few moments away from worries and problems*' [Mojgan, a 27-year-old woman]. Moreover, the existence of suitable facilities for users means that they do not need to go outside the park to meet their needs and desires and spend hours in this park without worries.

Table 4 The correlations between the items of positive mental health and the age, marital, and employment status of Fateh Garden's users (n = 76)

	Feeling cheerful	Interest in new activities	Feeling loved	Making up mind	Feeling confident	Close to other people	Good about myself	Thinking clearly	Dealing with problems well	Having energy	Interested in people	Feeling relaxed	Usefulness	Feeling optimism
Educational level	−0.111	*−0.245**	−0.117	−0.123	−0.120	−0.078	−0.048	−0.133	0.062	−0.037	0.068	−0.078	−0.191	−0.005
Marital status	0.061	0.209	0.177	*0.317***	*0.284**	*0.280**	0.028	0.009	*0.279**	0.168	*0.432***	0.109	*0.254**	0.133
Gender	0.104	0.071	0.046	0.038	0.096	*0.269**	0.061	0.012	0.071	0.169	0.065	0.017	0.088	0.003
Employment status	0.082	0.217	*0.301***	*0.332***	*0.362***	*0.426***	*0.288**	0.036	*0.312***	*0.229**	*0.462***	0.169	0.195	0.164
Age	0.117	0.165	*0.250**	*0.237**	*0.355***	*0.428***	0.212	−0.082	0.225	*0.233**	*0.551***	0.167	0.202	0.130

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Fig. 2 A picture of Fateh Garden users (*Source* Photo taken by the authors)

Another very important issue is the feeling of safety and security that allows users to visit this urban park with ease. Users generally feel very safe in Fateh Garden. One of the reasons for this feeling is the location of Fateh Garden in one of the best urban and economic areas of Karaj (Jahanshahr neighbourhood) and also the possibility of accessing it from several residential streets and alleys that are connected to the main streets. It is also surrounded in the western part by walls of houses and residential alleys. This situation has caused many users to look at the Fateh Garden as a refuge and a place to be safe: '*The Fateh Garden is a place where you can take refuge from the hustle and bustle of the city*' [Fereshteh, a 33-year-old woman]. Due to this peace and feeling of security, Fateh Garden has become a place to relieve sadness and fatigue: '*Looking at the trees of the Fateh Garden will take away all my sorrow*', '*When I feel sad, nothing makes me feel better like walking with a friend in this park*' [Somayeh, a 34-year-old woman, Hamid, a 30-year-old man]. This feature of Fateh Garden as a warm and invigorating place has caused people to look for sports activities and exciting events to instill a sense of hope and vitality. For some people, like 30-year-old Ketayoun, the trees of Fateh Garden act as their close friends and they can talk to these trees and get peace, and for some people, like 25-year-old Razieh, when they need to be alone, they can sit near the trees and talk to themselves.

5 Concluding Remarks

This study confirmed a generally beneficial relationship between Fateh Garden and the mental health of its users, especially during the pandemic. As one of Karaj's most popular urban parks, Fateh Garden could play a critical role in relieving the stress and worries of Karaj citizens during the epidemic. Users who were forced to stay at home due to the lockdown and their social interactions were severely reduced, found better mental health by visiting Fateh Garden and engaging in activities such as walking, exercising, playing chess and talking with friends. The relationship between Fateh Garden and mental health seems complex, with some affecting factors, such as gender, age, educational level, employment, and marital status. Although Fateh Garden has effectively increased the mental health of older, retired, and married users, no association was found between the positive mental health and gender and educational level of Fateh Garden's users. Furthermore, Fateh Garden has been effective in some items of positive mental health such as 'interest in new activities', 'feeling loved', 'having the energy to spare', 'making up my mind about things', 'feeling confident', 'feeling interested in other people', 'feeling close to other people', 'feeling good about myself', 'dealing with problems well', and 'perceptions of usefulness'. Moreover, the present study shows that people choose a park that reminds them of their favorite components and gives them peace of mind.

Acknowledgements For their cooperation, the authors would like to thank Fateh Garden users and officials. We appreciate their support and contribution in conducting and completing this study.

References

Annerstedt, M., Östergren, P. O., Björk, J., Grahn, P., Skärbäck, E., & Währborg, P. (2012). Green qualities in the neighbourhood and mental health—results from a longitudinal cohort study in Southern Sweden. *BMC Public Health, 12*, 337–349.

Antonovsky, A. (1996). The salutogenic model as a theory to guide health promotion. *Health Promotion International, 11*, 11–18.

Appelqvist-Schmidlechner, K., Vaara, J. P., Vasankari, T., Häkkinen, A., Mäntysaari, M., & Kyröläinen, H. (2020). Relationship between different domains of physical activity and positive mental health among young adult men. *BMC Public Health, 20*, 1116.

Arjmand, R. (2017). *Public urban space, gender, and segregation, women-only urban parks in Iran.* Routledge, London, and New York.

Astell-Burt, T., Mitchell, R., & Hartig, T. (2014). The association between green space and mental health varies across the lifecourse. A longitudinal study. *Journal of Epidemiology and Community Health, 68*, 578–583.

Bahriny, F., & Bell, C. (2020). Patterns of urban park use and their relationship to factors of quality: A case study of Tehran, Iran. *Sustainability, 12*, 1560.

Bedimo-Rung, A. L., Mowen, A. J., & Cohen, D. A. (2005). The significance of parks to physical activity and public health: A conceptual model. *American Journal of Preventive Medicine, 28*, 159–168.

Biddle, S. (2016). Physical activity and mental health: Evidence is growing. *World Psychiatry, 15*, 176–177.

Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Annals of the New York Academy of Sciences, 1249*, 118–136.

Chiesura, A. (2004). The role of urban parks for the sustainable city. *Landscape and Urban Planning, 68*, 129–138.

Callaghan, A., McCombe, G., Harrold, A., McMeel, C., Mills, G., Moore-Cherry, N., & Cullen, W. (2020). The impact of green spaces on mental health in urban settings: A scoping review. *Journal of Mental Health, 30*, 179–193.

Douglas, I. (2012). Urban ecology and urban ecosystems: Understanding the links to human health and well-being. *Current Opinion in Environmental Sustainability, 4*, 385–392.

Francis, J., Wood, L., Knuiman, M., & Giles-Corti, B. (2012). Quality or quantity? Exploring the relationship between public open space attributes and mental health in Perth, Western Australia. *Social Science & Medicine, 74*, 1570–1577.

Hami, A. (2009). *Users' preferences of usability of urban parks in Tabriz, Iran.* Universiti Putra Malaysia. http://psasir.upm.edu.my/id/eprint/11962

Hami, A., & Maruthaveeran, S. (2018). Public perception and perceived landscape function of urban park trees in Tabriz, Iran. *Landscape Online, 62*, 1–16.

Hamzenejad, M., & Gorji, F. (2018). Genealogy of recent parks of Tehran and analyzing their forming background. *Bagh-E Nazar, 14*, 29–46.

Houlden, V., Weich, S., & Jarvis, S. (2017). A cross-sectional analysis of green space prevalence and mental wellbeing in England. *BMC Public Health, 17*, 460–468.

Kaplan, R. (1984). Impact of urban nature: A theoretical analysis. *Urban Ecology, 8*, 189–197.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective.* CUP Archive.

Kaplan, R. (2001a). The nature of the view from home: Psychological benefits. *Environment and Behavior, 33*, 507–542.

Kaplan, S. (2001b). Meditation, restoration, and the management of mental fatigue. *Environment and Behavior, 33*, 480–506.

Khakzand, M., Gorji Mahlabani, Y., & Teymouri Gerdeh, S. (2015). A specific park for women or a public park: Women's preferences and perspectives on using city parks, case study: Four parks in Tehran. *Armanshahr Architecture & Urban Development*, *8*, 45–56.

Kuo, F., Sullivan, W., Coley, R., & Brunson, L. (1998). Fertile ground for community: Innercity neighbourhood common spaces. *American Journal of Community Psychology, 26*, 823–849.

Maller, C., Townsend, M., Pryor, A., Brown, P., & St Leger, L. (2006). Healthy nature healthy people: 'Contact with nature' as an upstream health promotion intervention for populations. *Health Promotion International, 21*, 45–54.

McEachan, R. R. C., Yang, T. C., Roberts, H., Pickett, K. E., Arseneau-Powell, D., Gidlow, C. J., Wright, J., & Nieuwenhuijsen, M. (2018). Availability, use of, and satisfaction with green space, and children's mental wellbeing at age 4 years in a multicultural, deprived, urban area: Results from the Born in Bradford cohort study. *The Lancet Planetary Health, 2*(6), e244–e254. https://doi.org/10.1016/S2542-5196(18)30119-0

Rismanchian, O. (2009). The role of green space development in renewing a degenerating neighbourhood, a case study from Tehran, Iran. In *The 5th international conference of CSAAR 2009: Sustainable Architecture and Urban Development, Libya.* https://www.researchgate.net/publication/320923321

Sarkar, C., Webster, C., Gallacher, J. (2018). Residential greenness and prevalence of major depressive disorders: a cross-sectional, observational, associational study of 94 879 adult UK Biobank participants. *The Lancet Planetary Health 2*(4):e162–e173

Statistical Center of Iran. (2018). Results of the 2016 national population and housing census. https://www.amar.org.ir/

Stewart-Brown, S., & Janmohamed, K. (2008). *Warwick-Edinburgh mental well-being scale (WEMWBS): User guide—version 1*. University of Warwick.

Sullivan, W. C., Kuo, F. E., & Depooter, S. F. (2004). The fruit of urban nature: Vital neighbourhood spaces. *Environment and Behavior, 36*, 678–700.

Taggart, F., Stewart-Brown, S., & Parkinson, J. (2016). *Warwick-Edinburgh mental well-being scale (WEMWBS): User guide—version 2*. NHS Health Scotland

Tennant, R., Hiller, L., Fishwick, R. et al. (2007). The Warwick-Edinburgh Mental Well-being Scale (WEMWBS): development and UK validation. *Health Qual Life Outcomes 5,* 63. https://doi.org/10.1186/1477-7525-5-63

The Ministry of Cultural Heritage, Tourism and Handicrafts (2006) https://www.mcth.ir/

Ulrich, R. S. (1986). Human responses to vegetation and landscapes. *Landscape and Urban Planning, 13*, 29–44.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*, 201–230.

Ward Thompson, C., Roe, J., Aspinall, P., Mitchell, R., Clow, A., & Miller, D. (2012). More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. *Landscape and Urban Planning, 105*, 221–229.

Wilson, E. O. (2007). Biophilia and the conservation ethic. In D. J. Penn & I. Mysterud (Eds.), *Evolutionary perspectives on environmental problems* (pp. 263–272). Routledge.

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough.' *Landscape and Urban Planning, 125*, 234–244.

Wood, L., Hooper, P., Foster, S., & Bull, F. (2017). Public green spaces and positive mental health-investigating the relationship between access, quantity, and types of parks and mental wellbeing. *Health & Place, 48*, 63–71.

World Health Organization (2018) Mental health: strengthening our response. Fact sheet. https://www.who.int/en/news-room/fact-sheets/detail/mental-health-strengthening-our-response

World Health Organization, Regional Office for Europe (2021) Green and blue spaces and mental health: New evidence and perspectives for action. World Health Organization. Regional Office for Europe.

Part II
Innovations in Buildings

Chapter 7
How to Deal with Epidemic Disaster in Buildings: Introduction to the Epidemic Prevention Design Standard of Residential Building

Zengwen Bu, Jishou Zhong, Lei Yuan, Xiaoqiang Gong, Jian Liu, Xinglin Jiang, Xinhong Cheng, Wanheng Yang, and Meng Tian

Abstract The outbreak of COVID-19 has brought new challenges to architectural design: how to reduce the impact of epidemic disasters through architectural design. The paper compared the number of casualties caused by epidemics and geological and meteorological disasters in history, and analyzed the ways of transmission of novel coronavirus and the building response strategies, concluding the necessity and importance of compiling epidemic prevention standards, and suggesting building epidemic prevention standards be taken as one of the basic standards for urban and building disaster prevention, to provide a safe barrier against epidemic disasters for a

Z. Bu
Redco Group, Shenzhen, Guangdong, China

J. Zhong
China Architectural Design and Research Institute Co., Ltd, Beijing, China

L. Yuan · M. Tian
Lab for Optimizing Design of Built Environment, School of Architecture and Urban Planning, Shenzhen University, Shenzhen, Guangdong, China

Z. Bu · X. Gong (✉)
Department of Electronics and Information Engineering, Bozhou University, Bozhou, Anhui, China
e-mail: gongxiaoqiang2018@email.szu.edu.cn

J. Liu
Ecological Technology Institute of Construction Engineering Shenzhen University, Shenzhen, Guangdong, China

X. Jiang
Zhubo Design Group Co., Ltd, Shenzhen, Guangdong, China

X. Cheng
Huasen Architecture and Engineering Design Consulting Co., Ltd., Guangzhou, Guangdong, China

W. Yang
Shenzhen Cenpoint Architects & Engineers Co., Ltd., Shenzhen, Guangdong, China

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_7

higher living environment in the future. And the paper introduced the starting point, positioning and thinking of compiling *Epidemic Prevention Design Standard Of Residential Building* (T/ASC27-2022), including the general principles, chapter division, epidemic prevention level of building and epidemic prevention design measures of different specialties providing a safe barrier against epidemic disasters when the next epidemic strikes. Finally, the specific case application of the epidemic prevention design of the Qianxihui project in Putian, Fujian Province is elaborated in detail.

Keywords SARS-CoV-2 · COVID-19 · Disease Disaster · Building Regulation · Design Standard · Epidemic Prevention Level

1 Introduction

It has been three years since the outbreak of novel coronavirus pneumonia (COVID-19) at the end of 2019, but with the constant variation of COVID-19, the epidemic situation is still grim. By the end of September 2022, the global cumulative infection has exceeded 600 million cases and death has exceeded 6.5 million cases (WHO, 2021).

According to *the Classification and specifications for natural disasters (GB/T28921-2012)*, natural disasters can be divided into five categories, including meteorological and hydrological disasters, geological and seismic disasters, marine disasters, biological disasters and ecological environmental disasters and the COVID-19 belongs to epidemic disasters in the category of biological disasters (NDRCC, 2012). According to the reference (Meng & Helang, 2009; Jeremy, 2020; Barry, 2021; Joshua, 2021; William, 2010; Nathan, 2014; M'ikanatha, 2020; Ahmed, 2013; Frank, 2019), the number of deaths caused by ten highly influential epidemic infectious disease disasters in human society in the past 250 years is shown in Table 1. According to rough statistics, more than 250 million people have died from epidemic disasters in the past 250 years.

According to the death toll statistics, as shown in Table 2, the death toll caused by 10 major geological earthquake disasters and meteorological and hydrological disasters is about 3.5 million (Meng & Helang, 2009).

Compared with Tables 1 and 2, the number of deaths caused by epidemic disasters in history is much higher than that caused by other natural disasters, such as geological earthquake disasters and meteorological and hydrological disasters.

Earthquakes, tsunamis, floods, fires, etc. can cause direct damage to the physical environment, while the physical interface and spatial correlation caused by epidemic disasters are vague, and their propagation paths are hidden, lasting for a long time, affecting a wide range of space, causing many casualties, and making prevention difficult, so that it is very easy to form a social- economic-environmental super disaster chain. However, there is no consensus between the global scientific community and the government on the specific measures to deal with such a huge disaster as COVID-19.

Table 1 Death toll of global epidemic disasters in recent 250 years

Number	Epidemic disaster		Outbreak time	Death toll (10,000 persons)
1	Smallpox		seventeenth and eighteenth centuries	15,000
2	The third pestis		1800–1950	1500
3	Cholera in the nineteenth century		1817–1823, 1827–1837, 1846–1863, 1863–1875, 1881–1896, 1899–1926	5000–10,000
4	Influenza	Influenza in Spanish	1918–1919	2500–4000
		Influenza in Asiatic	1957–1958	100–200
		Influenza in Russian	1889–1890	100
		Influenza in Hong Kong	1968–	100
5	Yellow fever in Philadelphia in 1793		1793	0.5
6	West Nile fever virus		1937–	0.1884
7	Poliomyelitis		twentieth centuries	100
8	Ebola		2014	1.1
9	SARS		2003	0.0908
10	COVID-19		2019–2022.6	650

Source Data from Meng and Helang (2009); Jeremy (2020), Barry (2021), Joshua (2021), William (2010), Nathan (2014), M'ikanatha (2020); Ahmed (2013); Frank (2019)

People spend 90% of their time inside buildings (Mohamad, 2021). The outbreak of the epidemic has changed people's production and lifestyle, raised new demands and challenges for the construction industry. The construction industry began to think: What natural disasters are more serious than the "COVID-19" epidemic? More than 85% of COVID-19 infection occurs in construction, and how does the construction industry respond? Is building epidemic prevention technology a healthy building or environmental sanitation or building disaster prevention? How can the construction epidemic prevention technology become the consensus of the engineering community and be effectively implemented?

With the emergence and evolution of architectural space changes caused by the COVID-19 pandemic, more and more scholars began to combine architectural design to achieve epidemic prevention by improving the architectural environment. Flexible (Bettaieb & Alsabban, 2020) and healthy, safe and sustainable architectural design application principles (D'Alessandro et al., 2020; Putra, 2021) have become the key qualities of anti-virus buildings. In addition, the design standards for building epidemic prevention are also constantly being explored (Gong et al., 2021; The IMMUNE Building Standard, 2021), providing building epidemic prevention design

Table 2 Death toll of 10 major geological earthquake disasters and meteorological and hydrological disasters in history (Meng & Helang, 2009)

Number	Geoseismic disasters and meteorological and hydrological disasters	Outbreak time	Death toll (10,000 persons)
1	Byzantine Antia Earthquake	526	25
2	Eastern Mediterranean earthquake	1201	110
3	Rainstorms and floods on the Yellow River in Zhengzhou	1887	90
4	Kanto Earthquake in Japan	1923	10
5	Drought in sub Saharan Africa	1968–1974	20
6	Tropical Storm Bora	1970	30
7	Tangshan Earthquake	1976	24
8	Indian Ocean tsunami	2004	20
9	Earthquake in northern Pakistan	2005	8.6
10	WenChuan Earthquake	2008	8.7

Source Data from Meng and Helang (2009)

(Fawwaz et al., 2021) by improving the layout of entrances and exits, space division and internal design, so as to reduce the virus transmission area. The influence of the contact distance between residents on the diffusion of respiratory droplets has been studied, improving the efficiency of ventilation strategies of existing buildings (Villafruela et al., 2016; Liu et al., 2017; Cortellessa et al., 2021) to effectively dilute and/or remove pollutants in the air (Li et al., 2007; Nielsen, 2009; Morawska et al., 2020; Kissler, 2020). Or the improvement of ventilation could effectively control the spread of viruses and other pollutants and reduce the risk of infection (Li, 2005; Bin et al., 2003; Jiang et al., 2009). However, in a bad outdoor air environment, the use of natural ventilation would cause outdoor virus carrying air to enter the room, increasing the risk of infection. When mechanical ventilation is used, viruses and bacteria attached to the filter screen will be brought into the room, further polluting. Ventilation is the main means to optimize the air environment inside the building, but it still has potential health risks (Wen et al., 2020; Ding et al., 2015).

Therefore, a "epidemic prevention" space simultaneously meeting the needs of preventing epidemic outbreaks now and in the future is designed, and accurate design indicators and space standards are established to enhance the building's resistance to potential epidemics, becoming a key challenge for the current architectural design.

Based on such thinking, at the beginning of the COVID-19 in March 2020, *the Guidelines for Epidemic prevention design of residential building* was approved by the China Architectural Society. After 18 months of preparation and four expert reviews within 8 months, the standard are released in September 2022 (http://www.chinaasc.org.cn/news/128931.html). Due to no ready-made design standard for building epidemic prevention at home and abroad for reference, the standard preparation process is also a process of exploration. This paper introduces the ideas

and main contents in the standard preparation process for reference in the future standard compilation and revision.

2 Challenges and Plans for Epidemic Prevention of Building

2.1 Challenges

The development history of architecture is the history of resisting natural disasters and constantly creating a safer and more comfortable living environment for human beings. Buildings are constantly developing in response to natural disasters such as earthquake, flood, lightning, fire, high temperature, and cold. With the gradual formation of industry consensus, national and industry standards have been established, including the Specification *for Seismic Design of Buildings (GB50011-2010)*, the *Specification for Fire Protection Design of Buildings (GB 50016-2014)*, the *Specification for Design of Urban Flood Control Engineering (GB/T 50805-2012)*, and the *Design specification for protection of structures against lightning (GB50057-2010)*, to effectively reduce losses caused by natural disasters. But how to deal with natural disasters such as the COVID-19, the construction industry is facing enormous challenges, triggered profound and extensive thinking in the industry.

The Diagnosis and Treatment Plan for Pneumonia Caused by novel coronavirus (Tentative Ninth Edition) issued by the National Health Commission of the People's Republic of China has identified three ways of novel coronavirus transmission (Gonhc, Osatcm, 2022):

(1) Respiratory droplets and close contact transmission are the main transmission routes;
(2) Aerosol propagation in a relatively closed environment;
(3) Contact transmission. People could also be infected after contacting with items contaminated by viruses.

The building is a relatively closed space environment, and is the place with the highest frequency of droplet propagation and close contact with personnel. Therefore, buildings have all three ways to transmit COVID-19. As shown in Fig. 1, according to the analysis of the survey data of 816 people infected with COVID-19 in Shenzhen from January to June 2022 (SMHC, 2022), 693 of them were infected in buildings, accounting for 85%, which indirectly indicates that buildings are related to the spread of the epidemic, and buildings have become an important link in epidemic prevention.

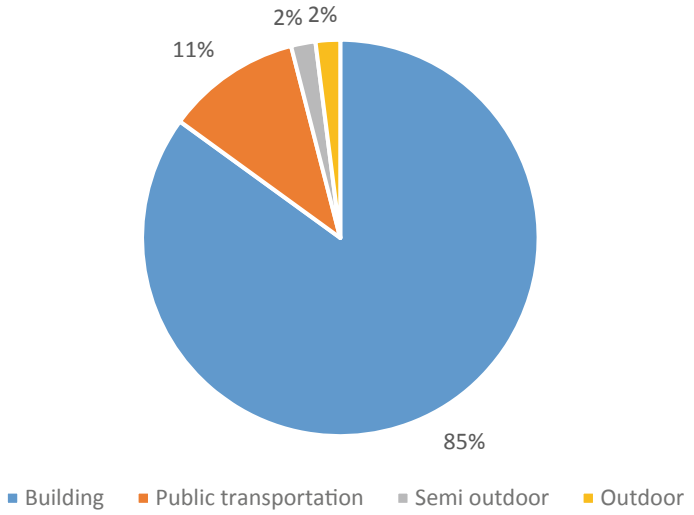


Fig. 1 Statistics of infection sites of confirmed cases in Shenzhen from January to June 2022. *Source* The data comes from the Shenzhen Municipal Health and Health Commission, and is compiled by the author.

2.2 Overall Solution for Epidemic Prevention of Building

Since the SARS epidemic in 2003, effective exploration has been made in the theoretical research of building epidemic prevention at home and abroad, including some feasible schemes, isolation wards, module hospital and other engineering practices (Wang et al., 2020; Tang, 2021), especially through the analysis of actual cases of infection transmitted by buildings (Kai, 2003; SCIHSARSOGHA (2003), providing a certain theoretical research for building epidemic prevention. However, these research papers, cases, lessons learned and technical measures are too scattered and lack the media of design standards, so they are difficult to be applied to other practical projects.

In addition, the design and construction of construction projects must be based on government regulations and industry standards, specifications and manuals, but research papers or reports are difficult to be used as the basis for design and construction. At the same time, the construction project is a systematic project, involving planning, architecture, structure, water supply and drainage, HVAC, electrical intelligence and other disciplines, and the coordination between disciplines has its own logic. While research papers or reports are mostly made by one person or several people based on one problem, they seldom consider the coordination with other majors. Building epidemic prevention involves basic medicine, clinical medicine, public health and preventive medicine, architecture, civil engineering and other disciplines. The research perspectives of different disciplines are relatively independent and single, resulting in a large number of research papers, but the research directions

are scattered, the quality is uneven, and the information is mixed, making front-line engineering and technical personnel at a loss.

Therefore, the technical standards for the design of building epidemic prevention need to be prepared. By gathering the wisdom and opinions of experts from multiple disciplines, the research results at home and abroad involving various disciplines of building epidemic prevention will be summarized, refined and screened, and the contradictions between disciplines will be unified and coordinated to form an industry standard that can be applied and implemented by engineering technicians.

2.3 Domestic and Foreign Standards Related to Building Epidemic Prevention

There are few standards related to building epidemic prevention at home and abroad. *IMMUNE Building Standard* issued by Belgium Health by Design Building Institute (HDBI) in June 2021. During the epidemic, China issued two epidemic prevention related standards, including *Guidelines for office buildings to* deal with "new coronavirus" operational management emergency measures (T/ASC 08-2020)(CADG, 2020) and *Operational Guide for Epidemic Prevention Design of Office, Residential and Medical Environment and Environmental Protection during the Epidemic Period* (MHURDPRC, 2020), as well as other epidemic prevention standards related to buildings led by the National Health Commission of the People's Republic of China. However, its government functions decide that these standards can only focus on the requirements of health indicators and the protection and disinfection in the construction operation and maintenance stage. However, from the perspective of the whole process of the construction project, the front-end planning and design epidemic prevention standards are missing. Therefore, the compilation of the design standards for building epidemic prevention is an important and urgent work to improve the standard system for building epidemic resistance.

3 Compilation Idea of Building Epidemic Prevention Design Standard

3.1 Components of Disaster Prevention Standards

Is building epidemic prevention an integral part of building health or building disaster prevention? This involves the division of functions among government departments and the centralized management and positioning of standards.

As for the standards for healthy buildings, there are *Assessment Standards for Healthy Buildings (T/ASC 02-2021)* and *Evaluating Standard for Healthy Housing (T/CECS 462-2017),* etc. in China. As for the standards of sanitation in buildings,

there are *Hygienic Management specification for Public Places (GB 37487-2019), Hygienic Standard for Hotel (GB 9663-1996)* and *Hygienic Standards for Dining (GB16153-1996),* etc.

Is it necessary to revise the existing health building standards and hygienic standards to add epidemic prevention content, or to prepare the building epidemic prevention standards separately? The following aspects can be analyzed:

(1) Epidemic disasters are both public health events and natural disasters. A separate standard system should be established to deal with major natural disasters. (2) Epidemic disasters are emergencies, the same as earthquake and fire, while health building technology and hygiene requirements are normal routine requirements, different in practice and requirements. (3) Building epidemic prevention involves many disciplines and contents, difficult to be covered in healthy building technology and sanitation technology. (4) The existing health standards focus on the requirements of health indicators and health services after the construction, while the health building standards are the evaluation standards. Therefore, the construction industry lacks the standards to guide engineering technicians in the technical link of building epidemic prevention design, so the health indicators and requirements related to epidemic prevention cannot be implemented. (5) As previously analyzed, the damage caused by epidemic disasters is huge, and its importance is far greater than the general health and hygiene requirements.

Therefore, the design standards for building epidemic prevention should be prepared separately by referring to the practices of buildings in dealing with natural disasters, from the aspects of harmfulness, nature of use, convenience, and collection of research results and experience on building epidemic prevention, and together with the existing disaster prevention specifications, form the basic standard system for building and urban disaster prevention, to protect the health and safety of residents.

In order to reduce technical risks, the design standards for building epidemic prevention are divided into two parts: *Standards for Epidemic Prevention Design of Residential Building* and *Standards for Epidemic Prevention Design of Public Building*. First, the standard of residential buildings with fewer building types and more people involved was compiled. Then, the research results of epidemic prevention were continuously absorbed in the process of use. After several years of use, the standard was finally combined into a *Design Standard for Epidemic Prevention of Building*. Based on the epidemic prevention design standards, the planning, design, construction, installation, acceptance, testing, evaluation, product, operation and maintenance and other standards of building epidemic prevention will be gradually completed, so as to establish a relatively complete standard system of building epidemic prevention, and minimize the threat of pandemic diseases mainly transmitted through air to cities and human beings.

3.2 Compilation Idea and Technical Measures of Standards

Different from the temporary documents such as management regulations issued during the epidemic, the *Standards for Epidemic Prevention Design of Residential Building* does not rely solely on administrative management, but uses a systematic approach to control the epidemic through the combination of construction technology and management. The control of epidemic situation should start from the architectural design, and then continue to improve. Therefore, epidemic prevention design standards can be used as the carrier for accumulating epidemic prevention research results and become the basis for epidemic prevention design of front-line engineering technicians.

3.2.1 General Rules for Preparation

There are many types of infectious diseases with different transmission routes. This standard focuses on COVID-19 and similar respiratory infectious diseases to guide and standardize the design of various architectural design disciplines and property services after completion, aiming to use architectural technology to block the transmission of viruses through droplets, aerosols and contacts, but it is not applicable to infectious diseases such as cholera transmitted through water bodies, AIDS transmitted through body fluids and blood.

On the one hand, the design of building epidemic prevention can reduce the risk of infection of people in the building; on the other hand, if people are infected, they can get relevant medical and health services nearby, quickly diagnose, isolate and treat, and reduce the probability of infecting others. Therefore, supporting medical and health care and services are also considered in the standard.

3.2.2 Division of Standard Sections

Building epidemic prevention technology involves many disciplines such as Building, general Plan, HVAC, water supply and drainage, electrical intelligence, as well as medical and health services, operation and maintenance after the building is completed. Therefore, in chapter division, in addition to an independent chapter for each discipline of architectural design, a separate chapter for medical and health services, operation and maintenance, plus general principles, terminology and basic provisions, a total of 10 chapters are set up.

In the process of standard preparation and standard review, whether the chapter of operation and maintenance is set in the design standard is controversial. The review expert group finally thinks it is necessary to retain it after many discussions. The reasons are as follows: (1) The operation and maintenance of buildings are really important. During the epidemic, every person isolated at home deeply felt that property services were indispensable and an important part of the epidemic

prevention work; (2) The requirements related to epidemic prevention design are not completely expressed in the design chapter, and need to be implemented in the operation and maintenance chapter; (3) Design is a phased work, while operation and maintenance is a continuous work. The design only needs to meet the current standards. After completion and delivery, the main work of the design is basically completed. The construction operation period will face a series of uncertainties such as the revision of standards and specifications, the decoration and change of buildings, so the operation and maintenance is the continuity of design services.

3.2.3 Design Level of Building Epidemic Prevention

During the epidemic, due to the complexity of building types, the risk of infection of personnel in different buildings is different, and the consequences of infection are also different, resulting in different losses. Therefore, the design level of building epidemic prevention is proposed to deal with different building infection risks.

Level I: for buildings with dense population, more close contact and weak immunity, once some people are infected, the consequences are relatively serious. Therefore, this type of building is defined as Level I epidemic prevention design level. Other places with special needs for epidemic prevention, such as infectious disease hospitals, barracks and command posts of chemical prevention forces, could also refer to the requirements of Level I. Kindergartens, nurseries and nursing homes are typical Level I epidemic prevention design buildings.

The reason why kindergartens and nurseries belong to Level I epidemic prevention design buildings is: (1) crowded: children's study and life are basically limited to one activity room, with an average student area of only 1.5–3 m^2. If a child is infected with an epidemic disease, the probability of transmission to other children is high. (2) More close contact and long time: children in a class spend 8–10 h playing, studying and living together. (3) Weak immunity: children have not yet completed all the vaccinations required by the state and have not established a complete immunity. Therefore, the kindergarten requires morning check every day when going to school, and the children's activity room requires daily disinfection. The existing norms and management systems have already taken some measures for building epidemic prevention.

Once the epidemic situation breaks out in nursing homes, it will have serious consequences. There are many elderly people, and their physical functions are degraded and their immune capacity is weak. Once they are infected with COVID-19 or other epidemic diseases, they may cause other complications. Therefore, the nursing home is a first-class epidemic prevention design building. In fact, in the early stage of the pandemic, infection in nursing homes would spread rapidly, with a high mortality rate (14–33%), and up to half of COVID-19 patients died in nursing homes (Ochi et al., 2021; Lau-Ng et al., 2020; White et al., 2020). In November 2020, 99 of 114 residents of Little Mountain Place Nursing Home in Vancouver tested positive for COVID-19, and at least 41 died (Amy, 2021).

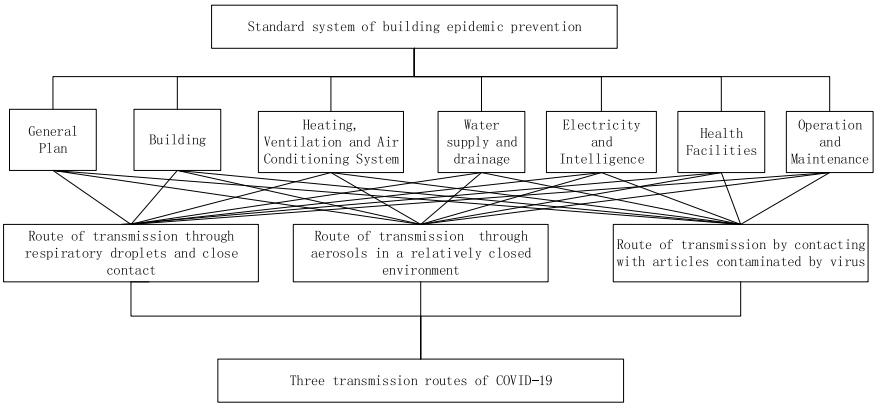


Fig. 2 Correspondence between epidemic transmission route and standard system. *Source Epidemic Prevention Design Standard of Residential Building* (T/ASC27-2022)

Level II: Ordinary houses, apartments, dormitories, etc., with low population density and relatively strong overall immunity, are classified as Level II for epidemic prevention design of building.

In consideration of practicability, economy and applicability, corresponding epidemic prevention design measures should be taken for buildings with different epidemic prevention design levels.

3.2.4 Technical Measures for Building Epidemic Prevention Design

The construction epidemic prevention measures in this standard aim at three transmission routes of COVID-19 and other epidemics, including respiratory droplets, aerosols and contact. Each construction discipline takes different design technical measures, as shown in Fig. 2 and *Epidemic Prevention Design Standard of Residential Building (T/ASC27-2022)* for details.

3.2.5 Safety of Epidemic Prevention Technology

The construction epidemic prevention measures must be safe to avoid other damage to the health of personnel due to epidemic prevention technology. From the perspective of the whole life cycle of the building, the epidemic situation is short, and the combination of epidemic prevention and control must be considered. The function and use of the building cannot be affected by the epidemic prevention measures, and the health performance of the building can be effectively improved through the epidemic prevention measures, such as improving the secondary pollution of the air conditioning and ventilation system during normal operation.

(1) Avoiding Ozone Generation

Different environmental disinfection technologies would be used in hospitals, kindergartens and some special places, but these technologies should avoid generating ozone. At the beginning of 2015, the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) released the *Position Paper on Filters and Air Purification Technologies* (ASHRAE, 2015), comprehensively reviewed the effectiveness of eight purification and disinfection technologies, including media filtration, electrostatic filtration, adsorption, ultraviolet light, photo catalysis, air purifier, ozone and ventilation, as well as their impact on indoor personnel's health, long-term effects and limitations, clear that: (1) mechanical filtration or porous media filtration has a very obvious filtering effect on particles, beneficial to human health; (2) The indoor environment should not use ozone for air purification. If the purification device generates a large amount of ozone during operation, it must be highly vigilant. In addition, ultraviolet ray has certain effect on inhibiting the activity or killing of viral microorganisms, but the possible ozone must be alert.

This standard adopts the viewpoint of ASHRAE and adopts more filtration purification methods. Although environmental disinfection measures have been designed for some functional rooms in the buildings of the first level epidemic prevention design level, the mode of "coexistence of human and machine" should be avoided for disinfection measures that may produce ozone.

(2) Improving Air Conditioning and Ventilation System

The actual use of the ventilation and air conditioning system in residential buildings exposed the problem of excessive microorganisms. The fresh air system designed for some residences is installed in the ceiling of the toilet or kitchen to save space, but these places are narrow and humid, and the filter is difficult to replace, often causing mildew and becoming a health hazard. And the experiment shows that the air conditioning system would have an aggravating effect on indoor air microbial pollution. The dynamic changes of microorganisms in the indoor air before and after the operation of the air conditioning system. Within 5 min after the operation of the air conditioning system, the number of indoor bacterial colonies rises sharply, which is 3 times that when the air conditioning is not running. After the operation is stable, the number of indoor bacterial colonies is stable at about 2 times that when the air conditioning is not running (Ding et al., 2015).

The pipes and filters of air conditioning and fresh air systems are suitable places for microorganisms to breed. Therefore, the standard proposes to adopt mold proof filter screen or other mold proof measures in the filter screen of the fresh air system to reduce the secondary pollution of the fresh air system. At the same time, according to the current national standards such as *Antibacterial and cleaning function for household and similar electrical appliances—Particular requirements of air cleaner (GB 21551.3-2010)* and *Antibacterial and cleaning function for household and similar electrical appliances-Particular requirements of air conditioner (GB 21551.6-2010)*, filter products with antibacterial and mildew resistant functions shall be selected, or fixed air purification function sections shall be set in the fresh air system to inhibit the breeding and transmission of germs in the air conditioning and fresh air system.

4 Design Case of Building Epidemic Prevention

Qianxihui Project, as shown in Fig. 3, is located in Xiuyu District, Putian City, Fujian Province, China, with Xiuyu Avenue in the east, planned road in the south, Houjing Road and planned land in the west, and planned road and Central Avenue green control belt in the north. The project covers an area of 154,359.07 m^2, with a total building area of 473,504.54 m^2. It belongs to the land for commercial, urban residential, education and service facilities, and is divided into three plots. Plot 1 is a commercial street, plot 2 is a residential area, and plot 3 is a residential area and a kindergarten. The project is designed in June 2021 and constructed in 2022. It is currently under construction. After the outbreak of COVID-19, the project development company Ligao Group issued the enterprise standard *Design Standards for Epidemic Prevention of Healthy Building* in March 2020. This project is designed according to this standard. Therefore, this project is selected as a case study of the design of building epidemic prevention.

Fig. 3 Aerial View of Qianxihui Square Project. *Source* Provided by Ligao Group

4.1 Design Principles and Measures for Epidemic Prevention

During the epidemic prevention design of the project, the following three principles shall be strictly followed: (1) The epidemic prevention design measures shall not conflict with the current design specifications; (2) It has little impact on the construction cost; (3) Optimize and improve the epidemic prevention function of the building, so that residents can feel the sense of security brought by epidemic prevention technology. Therefore, the following measures shall be taken in general plan design, building unit and house type design, electromechanical supporting technology and supporting services.

4.1.1 Epidemic Prevention Design of General Plan

(1) The natural ventilation of the site is optimized. Quanzhou is a hot summer and warm winter area, so the natural ventilation of buildings is particularly important for improving the living environment. The general layout design focuses on simulating and optimizing the natural ventilation of the building site, ensuring smooth ventilation in the areas where people walk and move in the residential area, avoiding vortex areas or windless areas, and providing reference for landscape design and activity site layout, as shown in Fig. 4.
(2) Suitable building density. The average building density is 26.38%, and the average floor area ratio is 2.49. The distance between high-rise residential buildings is large. The average distance between high-rise buildings in the dominant wind direction in spring is 30m, and the average distance between other buildings is 17m.
(3) Building blocks. The total building area of the project is large. In order to facilitate the control and service during the epidemic, four building blocks are divided from the south to the north, with an average land area of 35,000 m^2 for each block. As shown in Fig. 5.
(4) Non-contact community system. The main entrances and exits are designed with face recognition systems and intelligent infrared temperature measuring devices. Through the entrance-road-lobby-elevator-vestibule, you can enter the building non-contact throughout the whole journey home, which is convenient for owners and avoids cross contact of crowds, as shown in Fig. 6.
(5) Residential roads and communication and activity spaces are designed to reduce cross infection. The width of the road in the residential area is 2.5–4m, ensuring a safe distance of more than 1m when walking. Within 50m of the communication and activity space, there are public toilets and hand cleaning facilities.
(6) Reservation of epidemic prevention and service space. The entrance and the block are designed in combination with the landscape, and the collection and release places for non-contact takeout and express delivery are reserved to meet the requirements of nucleic acid detection and other services during the epidemic.

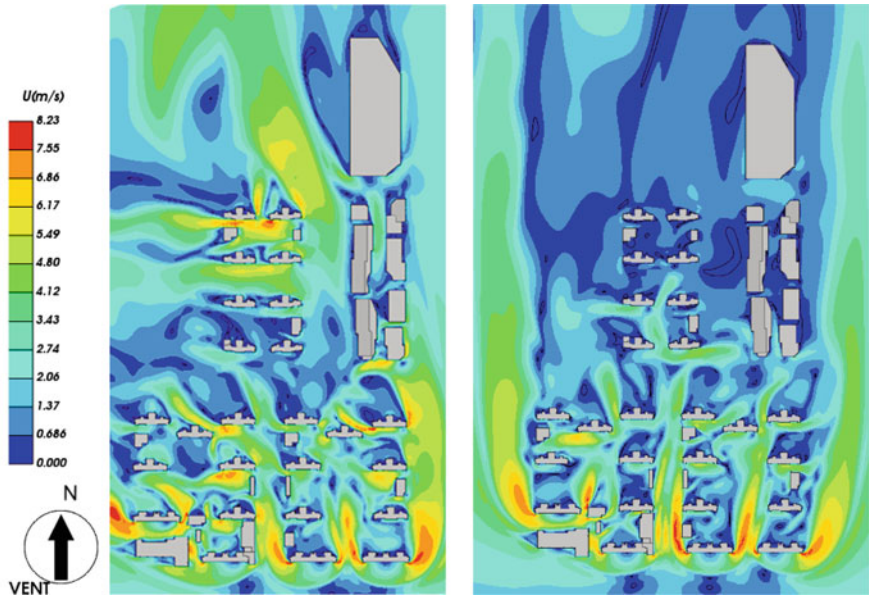


Fig. 4 Ventilation Simulation Diagram of Overall Building Layout in the Community. *Source* The picture is exported by the author according to the software simulation

4.1.2 Epidemic Prevention Design of Building Unit

(1) Combined with the natural ventilation simulation results of the general plan, the indoor ventilation of building unit is optimized to ensure good natural ventilation, as shown in Fig. 7.
(2) The entrance lobby and elevator on the first floor of each building are densely populated places. Therefore, the lobby on the first floor is designed with external windows for natural ventilation, and the elevator shaft is designed with louvers on the top floor that directly lead to the outside to ensure that the air supply in the elevator car is outdoor fresh air. Then the elevator car is equipped with a double speed fan, increasing the air supply volume in the car during the epidemic situation, and an epidemic prevention purifier, be opened for use during the epidemic situation. Finally, the elevator adopts touch free floor selection to reduce the chance of contact and infection.
(3) The three bedroom apartment has two bathrooms, one of which forms an independent suite with the bedroom. The external windows of the toilet are directly outward, and the distance between the external windows or exhaust outlets of the adjacent toilet is greater than 1m and they do not look at each other.
(4) The exhaust fan in the toilet is equipped with a check valve to prevent the outdoor air from back filling. The sanitary ware and floor drain in the toilet are all deep

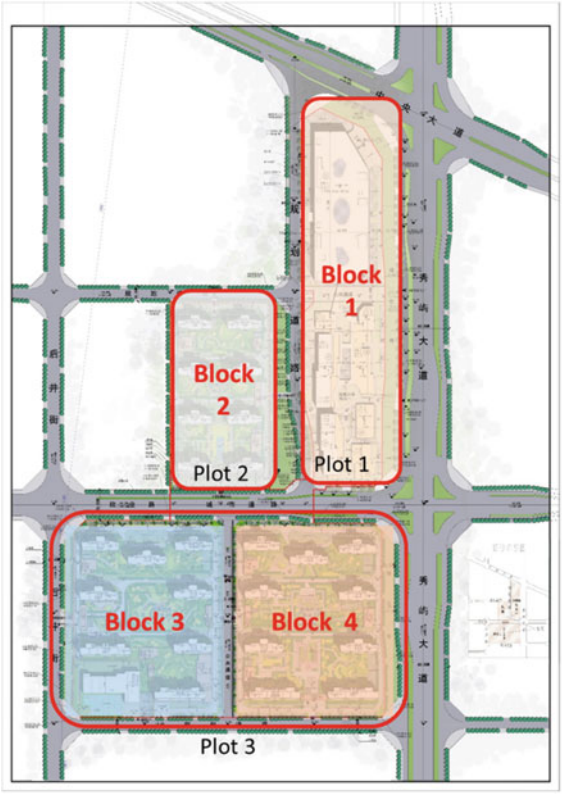


Fig. 5 Block division diagram. *Source* Provided by Ligao Group

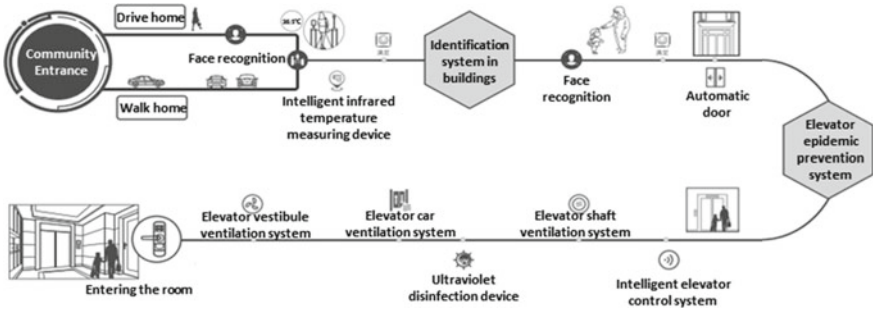


Fig. 6 Non-contact community system. *Source* Provided by Ligao Group

water sealed traps, and the water seal height is greater than 50mm. The toilet drainage riser is set in the tube well and separated from the water supply riser to prevent pollution caused by leakage. The roof vent pipe is 2m higher than the floor of the accessible roof to prevent the pollution in the drainage from being inhaled by personnel.

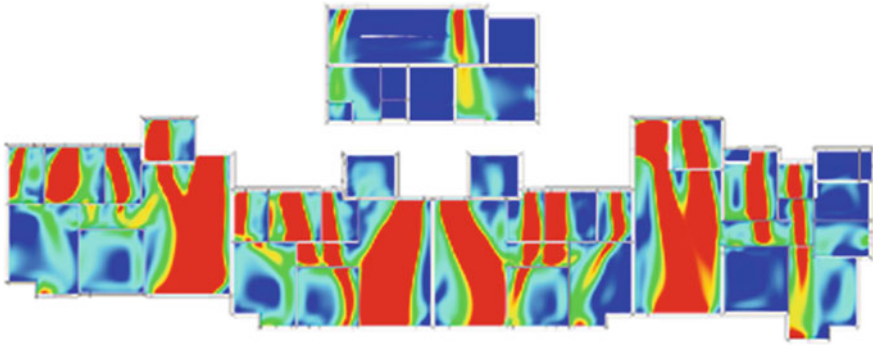


Fig. 7 Natural ventilation simulation of typical house type. *Source* The picture is exported by the author according to the software simulation

(5) The garbage room is equipped with disinfection, sterilization and deodorization devices, and the garbage point is equipped with a garbage container overflow monitoring and alarm system.

4.1.3 Health Supporting Facilities and Community Operation Services

(1) The project is equipped with a 150 m^2 community health service station and a 750 m^2 home care service station. Health management center, children's health insurance center, elderly care center, national health care center, sports rehabilitation center, neighborhood activity center and lifelong growth center are set up, and a telemedicine system is set up to provide medical security and home health care services for residents.
(2) Supporting fitness room. Provide fitness conditions to improve the immunity of community residents. The indoor sports and fitness space is well ventilated. The total area of the indoor fitness room is 510 m^2, and the total area of indoor and outdoor sports and fitness space is 5107 m^2, accounting for 1.08% of the project building area. The outdoor sports ground covers an area of 4195 m^2, accounting for 2.72% of the total land area. The bicycle parking space is set and the electric bicycle charging system is matched.
(3) The community has a smart health management platform. Various sensing equipment for environmental monitoring shall be set in the residential area to monitor the environmental quality of air, water, soil, CO, microorganism, etc. in the community, and integrate with the community digital operation platform to achieve linkage control with property stewards and health stewards, and maintain the healthy living environment of the community in real time.

5 Summary of Technical Measures for Epidemic Prevention of Project Buildings

The epidemic prevention design measures and technology of the Project are summarized in Table 7.

Since March 2020, Ligao Group has implemented healthy building and building epidemic prevention technology in more than 20 projects. From the application practice, the construction cost of building epidemic prevention technology is low, and the epidemic prevention design does not conflict with the existing building and residential design specifications. Market research shows that customers are sensitive to building epidemic prevention technology and have high acceptance.

6 Concluding Remarks

The epidemic has brought disasters to human beings and promoted the development of architectural design. Looking back on the epidemic situation in the past 100 years, the only certainty is that there will be new plagues and epidemics in the future. Plagues may not be predictable, but we should know that they will come again (Nathan, 2014).

Based on the research results and experience of building epidemic prevention, referring to the practice of building response to natural disasters, the design standards of building epidemic prevention were compiled, including the general principles, chapter division, epidemic prevention design level division, and epidemic prevention design measures of different specialties. Together with the existing disaster prevention specifications such as the Specification *for Seismic Design of Buildings (GB50011-2010)*, the *Specification for Fire Protection Design of Buildings (GB 50016–2014)*, the *Specification for Design of Urban Flood Control Engineering (GB/T 50805-2012)*, and the *Design specification for protection of structures against lightning (GB50057-2010)*, it forms the basic standard system for building and urban disaster prevention, protecting the health and safety of residents.

The *Standards for Epidemic Prevention Design of Residential Building* is a start, providing a guarantee for higher residential environment requirements of the future city through building epidemic prevention technology, and a safety barrier against epidemic disasters when the next epidemic strikes.

Table 7 Technical measures for building epidemic prevention of Quanzhou Yulongzhuang Project

Number	Specialty classification	Examples of epidemic prevention measures
1	General plan	(1) Carry out special analysis on natural ventilation in the general layout design to optimize the building layout; (2) The building density design of the project is appropriate, the average building density is controlled at 20%, and the building floor area ratio is 1.8; (3) The project is divided into 4 building blocks according to the site, high-rise and multi-storey building types; (4) The main pedestrian road in the residential area is 2.5m–4m wide, and there are public toilets and hand cleaning facilities within 50m of the communication and activity space; (5) The entrance and the neighborhood are designed in combination with the landscape, and non-contact takeout and express delivery places are reserved; (6) The main entrances and exits of the residential area are equipped with personnel information verification system and infrared temperature detection device
2	Building unit	(1) Special analysis on indoor natural ventilation; (2) The entrance lobby on the first floor of each building is designed with natural ventilation; The elevator shaft is connected to the atmosphere, and the elevator car ventilator is set with high and low gears, equipped with a car specific purification sterilizer; (3) The three bedroom house is equipped with two bathrooms, one of which forms an independent suite with the bedroom; (4) The sanitary ware and floor drain in the toilet are all equipped with deep water sealed traps, and the water seal height is greater than 50mm; (5) The toilet drainage riser is set in the tube well, separated from the water supply riser; (6) The roof vent pipe of the accessible roof is 2m higher than the floor to prevent the pollution in the drainage from being inhaled by personnel; (7) The garbage room is equipped with disinfection, sterilization and deodorization devices
3	Operation and maintenance	(1) The Internet platform for remote diagnosis and property services has been set up to reduce contact and facilitate medical treatment; (2) During the epidemic, the nucleic acid testing site was naturally ventilated; (3) The outdoor landscape water body and tap water are equipped with an online water quality monitoring system; (4) The outdoor air environment microorganism monitoring system is set; (5) The garbage container overflow monitoring alarm system is set at the garbage point

Source Prepared by the author

Acknowledgements This research is financially supported by Practical Research on Low Carbon and Healthy Building System in Fujian and Guangdong for China Construction Fangcheng Investment& Development Group Co., Ltd. (CSCECFC-2022-KJZX--06), Research on Intelligent System of Healthy Residential Buildings for Smart Building Research Center of China Real Estate Association, and Research and Verification of Epidemic Prevention System of Residential Buildings (Shenzhen science and technology plan project in engineering construction field in 2021).

References

Ahmed, A. K. (2013). Spillover: Animal infections and the next human pandemic. *The Yale Journal of Biology and Medicine, 86*(1), 107–112.

Amy, J. (2021). Administrator resigns at care home that was site of B.C.'s deadliest COVID-19 outbreak. Global News Posted February 19, 2021 https://globalnews.ca/news/7651253/administrator-resigns-little-mountain-place-covid-19/.

ASHRAE. (2015). ASHRAE Position Document on Filtration and Air Cleaning. NE • Atlanta, Georgia: 1–26. https://www.iaq-cpr.com/newsroom#:~:text=ASHRAE%20Position%20Document%20on%20Filtration%20and%20Air%20Cleaning,the%20health%20consequences%20of%20filtration%20and%20air%20cleaning.

Barry, J. (2021). *The great influenza: A story of the deadliest pandemic in history*. Penguin Books.

Bettaieb, D. M., & Alsabban. (2020). R. Emerging living styles post-COVID-19: Housing flexibility as a fundamental requirement for apartments in Jeddah. *Archnet IJAR, 15*, 28–50.

Bin, Z., Zhao, Z., & Xianting, L. (2003). Comparison of biological particles distribution in different ventil ated rooms. *Heating Ventilating & Air Conditioning, 30*(3), 179-182. (in Chinese).

CADG. (2020). Guidelines for office buildings to deal with "new coronavirus" operational management emergency measures: T/ASC 08–2020 Beijing: China Architectural Society: 1–8. (in Chinese).

Cortellessa, G., Stabile, L., Arpino, F., Faleiros, D.E., van den Bos, W., Morawska, L., & Buonanno, G. (2021). Close proximity risk assessment for SARS-CoV-2 infection. *The Science of the Total Environment, 794*, 148749-148749.

D'Alessandro, D., Gola, M., Appolloni, L., Dettori, M., Fara, G. M., Rebecchi, A., Settimo, G., Capolongo, S. (2020). COVID-19 and Living space challenge. Well-being and Public Health recommendations for a healthy, safe, and sustainable housing. *Acta Biomedica, 91*, 61–75.

Ding, L., Zha, X., Deng, K., & Yan, H. (2015). Wet-processing characteristics and inactivation dynamics model of indoor air microorganisms under air-conditioning system.

Fawwaz Alrebi, O., Obeidat, B., Atef Abdallah, I., Darwish, E.A., & Amhamed, A.I. (2021). Airflow dynamics in an emergency department: A CFD simulation study to analyse COVID-19 dispersion. *Alexandria Engineering Journal, 61*, 3435-3445.

Frank, M. S. (2019) Epidemics and Society: From the Black Death to the Present (Ji S,Cheng X,Trans.) Beijing: Central Compilation and Translation Press.2022. (in Chinese).

Gong, X., Liu, J., Wu, L., Bu, Z., & Zhu, Z. (2021). Development of a healthy assessment system for residential building epidemic prevention. *Building and Environment, 202*, 108038.

Gonhc, Osatcm. (2022). *Notice on printing and distributing the diagnosis and treatment plan for novel coronavirus Pneumonia (Trial Version 9)* (Guo Wei Ban Yi Han [2022] No. 71) (March 14, 2022) (October 17, 2022) http://www.gov.cn/zhengce/zhengceku/2022-03/15/content_5679257.htm. (in Chinese).

Jeremy, B. (2020). *Influenza: The hundred year hunt to cure the deadliest disease in history (Wang C, Trans.)*. Social Science Literature Press, Beijing. (2018) (in Chinese).

Jiang Y., Zhao, B. Li, X. Yang, X. Zhang Z., & Zhang Y. (2009). Investigating a safe ventilation rate for the prevention of indoor SARS transmission: An attempt based on a simulation approach. *Building Simulation, 2*, 281–289.

Joshua, L. (2021). *Epidemics: The impact of germs and their power over humanity*. (Li K, Trans.). Social Sciences Academic Press, Beijing. (2020) (in Chinese).

Kai, Y. (2003), Analysis on Residential Problems through the "Taoda Garden" Incident/KAI Yan. *Planners, s1*, 49–52. (in Chinese).

Kissler, S. M., Tedijanto, C., Goldstein, E., Grad, Y. H., & Lipsitch, M. (2020). Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science (New York, N.y.)*.

Lau-Ng, R., Caruso, L., & Perls T. T. (2020). COVID-19 deaths in long-term care facilities: A critical piece of the pandemic puzzle. *Journal of the American Geriatrics Society, 68*, 1895-1898.

Li, Y., Leung, G. M., Tang, J. W., Yang, X., Chao, C. Y., Lin, J. Z., Lu, J., Nielsen, P. V., Niu, J., Qian, H., Sleigh, A., Su, H. J., Sundell, J., Wong, T. W., & Yuen, P. L. (2007). Role of ventilation in airborne transmission of infectious agents in the built environment—A multidisciplinary systematic review. *Indoor Air, 17*(1), 2-18.

Li, Y. (2005). Engineering control of indoor infectious disease transmission—droplet diffusion and building ventilation Advances in New Technologies of Refrigeration and Air Conditioning. In: *Proceedings of the third symposium on new technologies of refrigeration and air conditioning* (pp. 18–22). (in Chinese).

Liu, L., Li, Y., Nielsen, P. V., Wei, J., & Jensen, R. L. (2017). Short-range airborne transmission of expiratory droplets between two people. *Indoor Air, 27*, 452–462.

M'ikanatha, N. M. (2020). The pandemic century: One hundred years of panic, hysteria and hubris. *Emerging Infectious Diseases, 26*(6), 1349. https://doi.org/10.3201/eid2606.191739.

William, H. M. (2010). Plagues and Peoples (Yu X, Bi H, Trans.). China Environmental Press, Beijing. (1976) (in Chinese).

Meng, L., & Helang, H. (2009). Major natural disasters in human history. *China Economic Weekly, 2009*(18), 2(in Chinese).

MHURDPRC. (2020). Notice of the General Office of the Ministry of Housing and Urban Rural Development on Printing and Distributing the Guidelines for Epidemic Prevention Design and Safety Guarantee of Indoor Air Environment in Public and Residential Buildings (Trial). http://js.xm.gov.cn/xxgk/zfxxgk/ml/gzdt/02/202006/t20200624_2457510.htm. (in Chinese).

Mohamad A., Burcin B.G., Simi H., et al. (2021) Ten questions concerning occupant health in buildings during normal operations and extreme events including the COVID-19 pandemic [J]. *Building and Environment,* 188: 107480. https://doi.org/10.1016/j.buildenv.2020.107480

Morawska, L., Tang, J. W., Bahnfleth, W. P., Bluyssen, P. M., Boerstra, A. C., Buonanno, G., Cao, J., Dancer, S. J., Floto, A., Franchimon, F. F., Haworth, C., Hogeling, J., Isaxon, C., Jimenez, J. L., Kurnitski, J., Li, Y., Loomans, M., Marks, G. B., Marr, L. C., Mazzarella, L., Melikov, A. K., Miller, S. L., Milton, D. K., Nazaroff, W. W., Nielsen, P. V., Noakes, C. J., Peccia, J., Querol, X., Sekhar, C., Seppänen, O., Tanabe, S., Tellier, R., Tham, K. W., Wargocki, P., Wierzbicka, A., & Yao, M. (2020). How can airborne transmission of COVID-19 indoors be minimised? *Environment International, 142*, 105832-105832.

Nathan, W. (2014). The Viral Storm: The Dawn of a New Pandemic Age (Shen J, Trans.). Hangzhou: Zhejiang People's Publishing House.2012. (in Chinese).

NDRCC, CMA, NMEFC. (2012). *The classification and specifications for natural disasters: GB/T 28921-2012* (pp. 1-5). General Administration of Quality Supervision, Inspection and Quarantine, National Standardization Administration, Beijing (in Chinese).

Nielsen, P. V. (2009). Control of airborne infectious diseases in ventilated spaces. *Journal of the Royal Society Interface, 6*, S747-S755.

Ochi, S., Murakami, M., Hasegawa, T., & Komagata, Y. (2021). Prevention and Control of COVID-19 in Imperfect Condition: Practical Guidelines for Nursing Homes by Japan Environment and Health Safety Organization (JEHSO). *International Journal of Environmental Research and Public Health, 18*(19), 10188. https://doi.org/10.3390/ijerph181910188

Putra, I. D. G. A. D. (2021). "Stay at home" for addressing COVID-19 protocol: Learning from the traditional Balinese house. Archnet-IJAR 2021, 15, 64–78.

SCIHSARSOGHA. (2003). Epidemic Investigation Report of Taoda Garden. Hong Kong. (in Chinese).
SMHC. (2022). COVID-19 daily update (2022–03–27) [2022–08–13]. http://wjw.sz.gov.cn/yqxx/content/post_9639496.html (in Chinese).
Tang, Q. (2021). The Huoshenshan Hospital Designing and Thinking of Construction of Post? Epidemic Medical Facilities. *New Architecture,2021*(1), 31-35. (in Chinese).
The IMMUNE Building Standard. (2021). Available online: https://immune-building.com/certification/ (accessed on 19 December 2021).
Villafruela, J. M., Olmedo, I., & José, J. F. (2016). Influence of human breathing modes on airborne cross infection risk. *Building and Environment, 106*, 340-351.
Wang, H., Jin, H., Chen, G., Ma, X., Xu, C., & Lu, X. (2020). Construction technology of negative pressure wards in Huoshenshan hospital. *Construction Technology, 49*(12):99-101. (in Chinese).
Wen, Y., Leng, J., Shen, X., Han, G., Sun, L., & Yu, F. (2020). Environmental and Health Effects of Ventilation in Subway Stations: A Literature Review. *International Journal of Environmental Research and Public Health, 17*.
White, E. M., Kosar C. M., Feifer R. A., Blackman C., Gravenstein S., Ouslander J., & Mor V. (2020). Variation in SARS-CoV-2 Prevalence in U.S. Skilled Nursing Facilities. *Journal of the American Geriatrics Society, 68*(10), 2167–2173. https://doi.org/10.1111/jgs.16752.
World Health Organization. (2021). WHO health emergency dashboard. World Health Organization, Geneva. https://covid19.who.int/.

Chapter 8
Impact of High-Touch Surfaces on Potential Transmission of Diseases in Offices and Public Buildings

Kazbek Aitbekov, Egemen Avcu, Galym Tokazhanov, Aidana Tleuken, Mert Guney, and Ferhat Karaca

Abstract The global pandemic caused by COVID-19 has raised serious concerns regarding the implementation of public health and social measures to prevent infections. The main routes of transmission include direct contact with at-risk patients and indirect contact with contaminated high-touch surfaces. High-touch surfaces (e.g., lift buttons, door handles, tables) are generally accepted as important spots of infection transmission. The present work investigates the transmission dynamics of surfaces in public and office environments via determination of highly touched surfaces. Additionally, self-inoculation in these environments was measured by the average number of hand-to-face contacts. The observation data were collected based on the direct physical contact with touched surfaces where subjects were the members and visitors of each environment. The results indicate that doorknobs and tables can be considered as highly touched surfaces at both investigated sites due to their higher contact frequency. The public environment involved a greater number of contacts per hour than the office environment. Anti-viral materials such as mineral nanocrystals, photocatalyst nanomaterials, and metallic nanoparticles should be chosen for hard surfaces in office environments, including door handles, tables, walls, and doorframes. As an example, Zinc (Zn), magnesium (Mg), and copper (Cu) are among the most prevalent metals that bind with viral proteins. Consequently, anti-viral coatings with intelligent release of Zn, Mg, and/or Cu ions could be developed and used to prevent the viability of SARS-CoV-2 virus on high-touch surfaces. It should be noted that increased human exposure to these ions would require a careful assessment of potential adverse health consequences along with measures targeting their minimization. The presented results provide understanding on transmission dynamics through

K. Aitbekov · G. Tokazhanov · A. Tleuken · M. Guney (✉) · F. Karaca
Department of Civil and Environmental Engineering, School of Engineering and Digital Sciences, The Environment & Resource Efficiency Cluster (EREC), Nazarbayev University, Kabanbay Batyr Ave. 53, Astana 010000, Kazakhstan
e-mail: mert.guney@nu.edu.kz

E. Avcu
Department of Machine and Metal Technologies, Ford Otosan Ihsaniye Automotive Vocational School, Kocaeli University, Kocaeli 41380, Turkey

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_8

surfaces in building environments, and ensuing discussion may help contribute to building sustainability and promote pandemic resilience via innovation in the built environment.

Keywords Building sustainability · Built environment · COVID-19 · Pandemic resilience · Pandemic sustainability · SARS-CoV-2 · Smart materials

1 Introduction

The role of environment in personal hygiene has gained importance in society due to the spread of COVID-19. The global pandemic caused by COVID-19 has brought strong considerations for implementing public health and social measures to minimize transmission and decrease the number of infected individuals as well as the mortality and morbidity rates (WHO, 2021). Infections are mainly transferred through direct contact with at-risk patients and indirect contact through contaminated high-touch surfaces and droplets (Anderson & O'Toole, 2008). Close contact between infected and uninfected people is considered as the main source of this respiratory infection. However, there is evidence that coronavirus could also be transmitted via contaminated surfaces (Cheng et al., 2020). Thus, one of the key drivers for viral contamination can be surfaces that people use and touch a daily basis: lift buttons, doorhandles, tables, chairs, children's toys, books, etc. (Ploux et al., 2010). Several studies have investigated the effect of the pandemic on the sustainability of residential buildings and urban development (e.g., Amoatey et al., 2020; Eykelbosh, 2020; D'Alessandro et al., 2020; Tokazhanov et al., 2020). For example, Tokazhanov et al. (2020) mentioned the crucial role of touching surfaces by highlighting the need to use touchless technologies and anti-viral surfaces. At the same time, Tleuken et al. (2021) highlighted the importance of touchless technologies for pandemic-resilient buildings. However, there is a lack of information regarding the transmission dynamics of pathogens in public and office environments (Pittet et al., 2006).

Considering that several microorganisms can persist on surfaces such as stainless steel and plastic from hours to several days, highly touched surfaces may be a reservoir of nosocomial pathogens and may indirectly contribute to virus transmission through hands. As the role of bacteria and virus transmission in public and office environments is currently not well known, these environments have been found vulnerable to COVID-19 and other infection outbreaks (Sehulster, et al., 2003). Recent studies concerning SARS-CoV-2, which causes COVID-19, have revealed that the virus can persist on stainless steel and plastic materials, remaining active for up to three days, and up to 24 h on a cupboard (Tokazhanov et al., 2020). *E. coli* and MRSA bacteria can survive on certain materials for up to several months (Whitehead & Verran, 2007) As these materials have been increasingly used in public areas due to their antibacterial features, durability, and resistance to environmental degradation, they may act as a reservoir for the SARS-CoV-2, which has an essential role

in the transmission dynamics of the virus. Therefore, it is crucial to determine potential frequently touched surfaces in office and public areas and evaluate its role for further transmission of infections. According to the recommendations of the Healthcare Infection Control Practices Advisory Committee, frequently touched surfaces should be disinfected and cleaned more frequently than surfaces with minimal contact (Scott, 2013).

Social measures have been conducted to limit the COVID-19 transmission across the world and, as a result, to reduce the incidence of morbidity. The main considerations are related to schools, educational institutions, workplace, accommodation sector, and living spaces. The World Health Organization (WHO, 2021) recommends regular cleaning and disinfection to limit the COVID-19 transmission as a universal safety measure depending on different transmission scenarios. For instance, protective, environmental, surveillance and response, physical distancing, and travel-related measures have been globally implemented to prevent the spread of viruses. WHO (2021) also recommends tailoring disinfection, cleaning, and ventilation activities specifically in public areas in terms of environmental measures. Thus, it is essential to understand better the transmission dynamics through surfaces in order to optimize the disinfection and cleaning activities depending on the environment, which will significantly contribute to the sustainability of building materials.

The present study primarily aims to determine frequently touched surfaces and to examine transmission dynamics in office and public environments. The observation data have been collected considering the direct physical contact with touched surfaces, and the subjects were members and visitors of each environment. In addition, self-inoculation in these environments was measured by observing the average number of hand-to-face contacts. The study contributes to the understanding of transmission dynamics through surfaces in various environments, thereby may help enhance the sustainability of building materials.

2 Methods

Since people spend significant time on public and work environments during which they come into direct or indirect contact with numerous others, two observation sessions were conducted to determine frequently touched surfaces in public and office environments and to examine the similarities and differences in common surfaces between the two environments. The public environment was considered as a place where anyone can visit and interact with the environment including people who work there. Office environment was considered a space where only office workers are located with no interference from outside. The observation data was collected considering the direct physical contact with touched surfaces without violating human rights and personal space. The observations have been conducted at available public and office facilities in Karaganda, Kazakhstan. The criteria for enrolment were the willingness of sites to provide their space for conducting two observation sessions. Each facility received a specification about the proposed session, and all participants were

instructed before observation. Observations did not address the further transmission from one built-in environment to another. Obtained results then used to analyse and discuss the role of contaminated surfaces in build-in environments.

2.1 Observation Session A

One of the objectives of the sessions was to evaluate the role of daily routine and different conditions on the number of touched surfaces. The subjects were members and visitors of each environment. The primary objective was to identify highly touched surfaces; thus the age category of the subjects was not taken into consideration. During the observation, direct physical contact was counted and recorded; therefore, visitors of public and office places were not informed to maximize daily routine scenarios. Although visitors were informed about the planned observation and video recordings, there was no danger, potential risk of hazard, or gathering of confidential information.

The duration of the observation was seven days, with three hours per day and twenty-one hours in total. The reason for the chosen duration is that it represents a compromise between having sufficient time to obtain reasonable values and having values from different days of the week. It was stated that the criteria for enrolment in the observation agree with the director, and members of the facility have the willingness to provide the site. In this context, a florist business was confirmed as the public environment for the proposed observation. This business has a lot of visitors making it suitable for representing a public environment, and a relatively small space which makes is easy to conduct observations. The flower business office had two main doors, one leading to the room with flowers and the other to the staff restroom. There were also two tables, two cupboards with staff equipment, one water dispenser, and two disinfectant dispensers near two main entrances. For the public environment, the time to perform the investigation varied on purpose since the number of visitors and their daily routine may vary during the day.

A design studio was enrolled in the observation session as an office environment since the place represents well the office environment with no visitors. The proposed site had one main entrance and additional five doors to the rooms, such as two bathrooms, two cabinets, and one kitchen zone. Subjects of the observation were members of the studio, including six people and one director of the workplace. No visitors were recorded during the observation sessions of the office area. The time chosen was the same every day as there was the same daily routine in general. The office building equipment included nine tables, one printer, two coffee machines, one water dispenser, one refrigerator, and 13 cupboards.

Interactions with surfaces were reported starting at a baseline day numbered as one and days after that numbered as two and three. For each day, the number of contacts with each particular surface was separately recorded. The number of members and visitors was also recorded. By the end of the session, the total number of contacts for each surface was calculated, and the average number of interactions with surfaces

was determined. To further discuss transmission dynamics, the surfaces were then classified as high, medium, and low touched surfaces by calculating the average number of contacts per hour i.e., high touched surfaces: 15 or more contacts per hour, medium touched surfaces: from 5 to 15 contacts per hour,low touched surfaces: from 1 to 5 contacts per hour.

2.2 Observation Session B

Additional attention was paid to self-inoculation, which was considered a potential transmission source. Self-inoculation describes the process of contact transmission that occurs when a subject with contaminated hands touches his or her own body and spreads contaminated components to the body site. (Nicas & Best, 2008). This second observation session aimed to investigate the average number of hand-to-face contacts to evaluate the relationship between face touching and transmission dynamics. The observation procedure consisted of video recording of the subject and reporting the number and type of face-touching. A total of seven sessions of one-hour video recording have been performed via a video camera. The average number of contacts to the mucosal area such as mouth, eyes, and nose and the non-mucosal regions such as hairs, cheeks, and chin was reported.

3 Results and Discussion

3.1 Observation Session A

3.1.1 Public Area

In this session, a total of 173 subjects (Table 1) took participation, making a total of 2,747 touches (Table 2) with surfaces over 21 h observed. During the observation sessions conducted every day for 3 h at different periods each day, only direct contact with surfaces was counted, and touches were recorded with a particular approach. For instance, if subjects used the tablet (placed in the establishment to manage business transactions) continuously, it would be counted as one contact. The same approach was used for other surfaces i.e., multiple touches with the same object have been counted as one. In addition, contact with phones were not included.

Table 1 Number of visitors and members observed per day

Days observed	1	2	3	4	5	6	7	Total
Number of visitors	23	9	5	21	8	19	67	173
Number of members	3	3	3	3	3	3	3	

Table 2 Number of contacts with surfaces in public environment

Surfaces	Days observed							Total number of contacts	Average contacts per hour
	1	2	3	4	5	6	7		
Doorknobs	92	67	43	86	53	97	234	672	32.0
Table	43	58	61	51	43	79	169	504	24.0
Hard money	17	6	6	6	3	28	46	107	5.1
Plastic bucket	7	19	9	15	7	23	27	112	5.3
Cashbox	33	15	7	43	14	36	79	107	5.1
Tablet	67	46	17	56	23	75	132	416	19.8
Knife	27	7	2	9	1	2	19	67	2.7
Water dispenser	5	9	11	16	9	13	23	86	4.1
Light switch	3	3	2	2	2	4	2	18	0.7
Chairs	9	13	5	7	5	11	5	55	2.6
Trash can	13	7	5	3	2	7	13	50	2.4
Cables	3	2	1	2	1	1	1	11	0.5
Toys	5	1	3	7	3	6	9	34	1.6
Cupboard	11	7	16	13	12	13	15	87	4.1
Cups	7	11	13	23	5	5	3	67	3.2
Flowers	34	21	5	19	9	23	54	165	7.9
Disinfectant dispenser	25	16	9	25	13	25	76	189	9.0
Grand total								2,747	130

Doorknobs, tables, and tablets were the most touched surfaces in the facility (Fig. 1). Thereafter, flowers and disinfectant dispensers were also touched with high frequency. According to the results, in the flower business, surfaces such as doorknobs, tables, and tablet were considered highly touched surfaces as there were more than 15 contacts per hour on average. Medium touched surfaces included the disinfectant dispenser, flowers, plastic bucket, hard money, and cashbox (from 5 to 15 touches per hour). Surfaces such as water dispensers, cupboards, cups, knives, chairs, trash can, toys, light switch, and cables were considered low touched surfaces as there were less than 5 contacts per hour.

3.1.2 Office Area

As a result, during the session with seven subjects were observed, and a total of 1,790 touches were reported. Table 3 presents the total number of contacts by following the same principle about continuously touched surfaces. It is important to emphasize that phones, computers, keyboards, and mouses were not considered because most of the time subjects spend on designing; thus, it would be a complex process that requires a video recording. After that, the total number of touches was calculated,

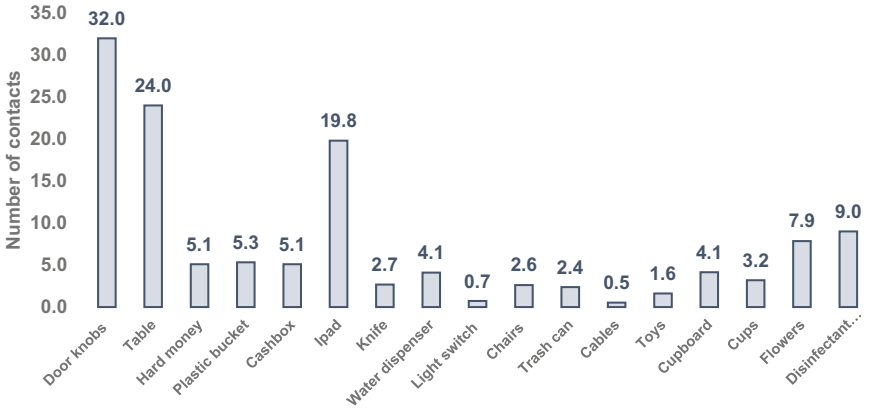


Fig. 1 Average number of contacts per hour observed in the public environment

and the average number per hour was obtained (Table 3). During the observation in the office environment, there were 85.2 contacts with surfaces per hour.

According to the results, doorknobs and tables can be classified as highly touched surfaces (>15 contacts with them per hour; 17.3 and 20.9, respectively). Figure 2 shows a graphical representation of the obtained results, showing that these surfaces

Table 3 Number of contacts with surfaces in office environment

Surfaces	Days observed							Total number of contacts	Average contacts per hour
	1	2	3	4	5	6	7		
Doorknobs	67	46	39	63	57	47	47	364	17.3
	89	68	61	54	39	81	45	439	20.9
Printer	31	15	6	6	4	13	9	81	3.9
Coffee machine	15	9	5	7	6	3	5	53	2.5
Cups	23	13	13	23	14	16	13	116	5.5
Water dispenser	9	16	11	7	14	17	16	89	4.2
Papers	47	23	3	12	6	15	10	116	5.5
Chairs	16	11	12	7	12	9	4	71	3.4
Light switch	9	8	10	6	8	5	7	53	2.5
Refrigerator	9	5	3	5	6	7	5	40	1.9
Ruler	17	24	5	14	4	21	3	88	4.2
Soap dispenser	24	19	12	16	13	15	11	110	5.2
Trash can	6	10	4	7	2	4	2	35	1.7
Cupboard	17	13	11	7	15	18	12	93	4.4
Cables	16	9	5	3	1	3	5	42	2.0
Grand total								1,790	85.2

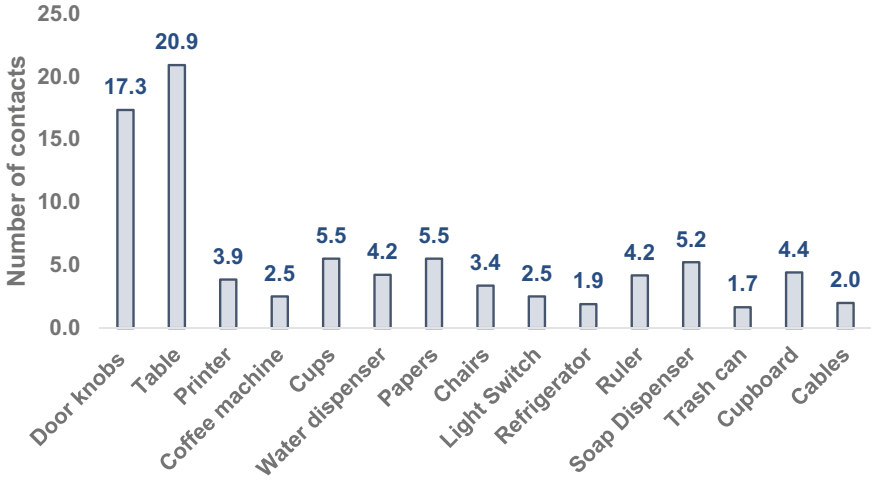


Fig. 2 Average number of contacts per hour observed in the office environment

have been touched much more than any other surface. Surfaces such as cups, papers, and soap dispensers considered medium touched surfaces; on average, they were touched slightly more than five times per hour. The remaining surfaces were classified as low touched surfaces, namely printer, coffee machine, water dispenser, chairs, light switch, refrigerator, ruler, trash can, cupboard, and cables.

In general, there was a similarity between high touch surfaces as doorknobs and tables in both sites touched at a higher frequency than other surfaces. The only difference was the tablet that the flower facility members used to manage the business; it was also considered a highly touched surface. Furthermore, due to the daily routine and different conditions in the workplace, the number of contacts in the public environment was higher than in the office environment. It is assumed that the higher rate of contacts and daily visits of clients to the flower business would increase the transmission of bacteria and viruses. In addition, there was a cash exchange on the public site, which means that there would be further exchange among visitors and members of the business. According to the persistence assessment of some bacteria on contaminated paper, it was highlighted that *E. coli*, *E. hirae*, and *S. aureus* could remain active for up to 24 h and be inactivated after seven days (Hubner et al., 2011). Therefore, cash exchange can increase the transmissibility of pathogens to hands and back.

Different daily routines and conditions throughout the day affected the list of surfaces and associated contacts. As a result, only highly touched surfaces were similar; however, medium and low touched surfaces differed in the type of surfaces. Kurgat et al (2019) showed that refrigerator, drawer handles, soap dispensers, and push bars were the main contaminated surfaces, indicating that affected surfaces may differ depending on the environment. It is important to note that different environments require specific cleaning and disinfection practices and safety measures.

Considering that the regular cleaning of high-touch surfaces reduces the virus spread (Zhang & Li, 2018), it is important to identify them for each different environment. Furthermore, according to the classification performed based on the results, cleaning and disinfection practices might be improved and renewed. For example, cold-spray copper-based coatings, anodized-aluminium, and quaternary ammonium compounds (proven to be efficient against SARS-CoV-2 (Irissou et al., 2020; Jann et al., 2021)) can be used for high-touch surfaces as an improved disinfection practice. According to the WHO, cleaning surfaces by itself do not ensure removing or killing microorganisms as mechanical action (e.g., scrubbing) is required to remove some dirt, secretions, excretions, and debris. Surface disinfection should be applied as most microorganisms with direct disinfectant contact might be inactivated (WHO, 2020).

3.2 Observation Session B

There were 135 face-touching cases made by one participant who consented before video recording. Mucosal regions have been involved in 37.8% of face touches (Table 4), whereas 62.2% of touches have been to non-mucosal regions (Table 5). Considering the total of 51 contacts with the mucosal region (Table 4), most involved the mouth (25 touches; 3.6 touches per hour), followed by the nose (21 touches; 3.0 touches per hour) and eyes (six touches; 0.9 touches per hour). There was a total of 84 touches with non-mucosal regions (Table 5), cheeks were touched with higher frequency (37 touches; 5.3 touches per hour) than chin (33 touches; 4.7 times per hour) and hair (14 touches; 2.0 touches per hour).

There is still a lack of literature regarding the transmission of common respiratory infections through self-inoculation. Nevertheless, it is considered that contaminated hands have the potential to spread respiratory infections (Kwok et al., 2015). For instance, Staphylococcus aureus might be self-inoculated through face touching due to roughly 25% of this bacterium carried in the nasal mucosa of the community, and individuals in close contact with potential carries might be infected (Munckhof et al., 2009; Wertheim et al., 2005). Self-inoculation might occur if people do not comply with hand hygiene after contact with surfaces or after greetings with hands and make further contact with vulnerable body sites such as the nose, mouth, and eyes (Sax

Table 4 The number of contacts with mucosal area observed in 1 h

Mucosal area	Days observed							Total number of contacts	Average contacts per hour
	1	2	3	4	5	6	7		
Mouth	2	3	4	3	5	5	3	25	3.6
Eyes	1	2	0	0	2	0	1	6	0.9
Nose	4	5	2	3	1	2	4	21	3.0
Total								51	7.3

Table 5 The number of contacts with non-mucosal area observed in 1 h

Non-mucosal area	Days observed							Total number of contacts	Average contacts per hour
	1	2	3	4	5	6	7		
Hair	3	1	1	2	4	1	2	14	2.0
Cheeks	7	5	3	4	7	5	6	37	5.3
Chin	5	4	3	7	3	4	7	33	4.7
Total								84	12.0

et al., 2007). One of the major drivers for the transmission of respiratory pathogens in the healthcare environment is contaminated hands (Pittet et al., 2006). Considering a recent finding where 8.3% of high-touch surface samples were contaminated with SARS-CoV-2, the role of self-inoculation only becomes more critical (Harvey et al., 2021). Due to a lack of data regarding the transmission of pathogens and the role of contaminated hands outside of healthcare systems, it is important to evaluate the face-touching behaviour in different settings. Approximately 19 touches per hour were observed, of which 37.8% involved the mucosal areas. These findings support the role of contaminated hands in the further transmission of infections, the number of potentially infected people, and the importance of hand hygiene compliance.

This observation has several limitations related to a considerable causal link which requires enrolment of more subjects, prospective follow-up, and face-touching behaviour in different settings. Furthermore, there might be an intertwining of various aspects, such as persistence of pathogens, different results related to age category, and related climate conditions, which cannot be easily controlled. The obtained results determine the average number of touches and evaluate face-touching behaviour.

3.3 A Brief Overview of the Development, Implementation, and Suggestions for Anti-viral Materials for High-Touch Surfaces

As the present study reveals highly touched surfaces in office and public buildings that may increase the transmission of viruses and bacteria, it is imperative that new materials (i.e., smart/intelligent and anti-viral materials) for preventing infection to be developed quickly and effectively. Recent studies demonstrate the potential of photocatalytic surfaces for the inactivation of SARS-CoV-2 as they permanently oxidize, inactivate, and destroy microorganisms under normal ambient lighting conditions, i.e., they are also effective in an indoor environment (Prakash et al., 2022). Recent studies, for instance, highlight the efficient disinfection of SARS-CoV-2 with TiO_2 photocatalysts (Prakash et al., 2022). In addition, the development of antiviral coatings (e.g., silver, gold, and copper nanocoating, titanium-based coatings, and carbon coating) for high-touch surfaces in the built environment can prevent the spread of

viral particles and thus inhibit the transmission of viruses (Shirvanimoghaddam et al., 2021).

Zinc (Zn), magnesium (Mg), and copper (Cu) are among the most prevalent metals that bind with viral proteins; thus, anti-viral coatings with intelligent release of their ions can be developed to prevent viability of SARS-CoV-2 viruses on high touch surfaces (Saud et al., 2022). Nonetheless, increased exposure to these ions would necessarily require careful consideration and management of adverse health consequences. Topography-mediated anti-viral surfaces obtained by various surface treatment routes (such as etching and laser-treatment) may be another promising strategy to fight against Covid-19 (Schio et al., 2021). For instance, aluminium 6063 alloy with nanostructured surfaces has recently been used for door frames and window panels (Rakowska et al., 2021). Antimicrobial properties of different surface materials and coatings have been the subject of intense research, whereas antiviral or virucidal properties of materials are still less well understood (Rakowska et al., 2021). Moreover, despite the fact that anti-viral materials and coatings have a wide variety of applications, such as antiviral food packaging and food contact surfaces, their use in hard surfaces in building environments, where durability, stability, and non-flammability are essential, is still limited. Consequently, accelerated future studies on developing anti-viral materials and coatings that can be applied to high-touch hard surfaces in public and office environments are anticipated to increase exponentially.

4 Conclusion

The present research focused on a better understanding of the transmission dynamics in public and office environments by conducting two observations on the frequency of contact between subjects and environmental surfaces in both sites. The first observation session aimed to identify frequently touched surfaces in public and office environments and determine similarities and differences. The obtained results demonstrate that doorknobs and tables were highly touched surfaces in both sites with a higher frequency of contacts. However, medium and low touched surfaces differed in the number of contacts and types of the surface due to the different conditions and daily routines. In general, the public environment involved a greater number of contacts per hour compared to the office building. Cleaning and disinfection measures should be applied by priority to maximize the effectiveness of such measures. Ideally, regardless of the average number of contacts, all environmental surfaces should be subjected to cleaning and disinfection measures; however, they should be subjected to these measures at least in priority, considering a great number of surfaces. Self-inoculation might occur during the inoculation from the mouth and nose due to the high touching frequency of these mucosal regions. Further investigation with stimulation of bacteria and virus transmission in different conditions could better elucidate the role of self-inoculation. Overall, it is necessary to increase community awareness by paying attention to public health and safety measures to limit infection

transmission in community settings. Non-healthcare environments should be examined to expand the knowledge in transmission dynamics. The study contributes to the development of smart anti-virus coating materials by elucidating the high-touch surfaces and evaluating potential self-inoculation in a working environment. The results can be used to develop a protocol for high-touch surface identification, and further application of anti-viral coatings for identified surfaces.

Acknowledgements The authors acknowledge the financial support from Nazarbayev University Faculty Development Competitive Research Grant Program (FDCRGP, Funder Project Reference: 280720FD1904).

References

Amoatey, P., Omidvarborna, H., Baawain, M. S., & Al-Mamun, A. (2020). Impact of building ventilation systems and habitual indoor incense burning on SARS-CoV-2 virus transmissions in Middle Eastern countries. *The Science of the Total Environment, 733*, 139356. https://doi.org/10.1016/j.scitotenv.2020.139356

Anderson, G. G., & O'Toole, G. A. (2008). Innate and induced resistance mechanisms of bacterial biofilms. *Current Topics in Microbiology and Immunology, 322*, 85–105. https://doi.org/10.1007/978-3-540-75418-3_5

Cheng, V. C. C., Wong, S. C., Chen, J. H. K., Yip, C. C. Y., Chuang, V. W. M., Tsang, O. T. Y., Sridhar, S., Chan, J. F. W., Ho, P. L., & Yuen, K. Y. (2020). Escalating infection control response to the rapidly evolving epidemiology of the coronavirus disease 2019 (COVID-19) due to SARS-CoV-2 in Hong Kong. *Infection Control and Hospital Epidemiology, 41*(5), 493–498. https://doi.org/10.1017/ice.2020.58

D'Alessandro, D., Gola, M., Appolloni, L., Dettori, M., Fara, G. M., Rebecchi, A., Settimo, G., & Capolongo, S. (2020). COVID-19 and Living space challenge. Well-being and Public Health recommendations for a healthy, safe, and sustainable housing. *Acta Bio-medica: Atenei Parmensis*, *91*(9-S), 61–75. https://doi.org/10.23750/abm.v91i9-S.10115.

Eykelbosh, A. (2020). *COVID - 19 Precautions for Multi-unit Residential Buildings.* National Collaborating Centre for Environmental Health. https://ncceh.ca/sites/default/files/COVID-19%20Precautions%20for%20Multiunit%20Residential%20Buildings%20-%20March%2031%202020.pdf.

Harvey, A. P., Fuhrmeister, E. R., Cantrell, M. E., Pitol, A. K., Swarthout, J. M., Powers, J. E., Nadimpalli, M. L., Julian, T. R., & Pickering, A. J. (2021). Longitudinal Monitoring of SARS-CoV-2 RNA on High-Touch Surfaces in a Community Setting. *Environmental Science & Technology Letters, 8*(2), 168–175. https://doi.org/10.1021/acs.estlett.0c00875

Hübner, M., Simion, C.E., Tomescu-Stănoiu, A., Pokhrel, S., Bârsan, N., & Weimar, U. (2011). Influence of humidity on CO sensing with p-type CuO thick film gas sensors. *Sensors and Actuators B: Chemical*, *153* (2). https://doi.org/10.1016/j.snb.2010.10.046

Hübner, N. O., Hübner, C., Kramer, A., & Assadian, O. (2011b). Survival of bacterial pathogens on paper and bacterial retrieval from paper to hands: Preliminary results. *The American Journal of Nursing, 111*(12), 30–36. https://doi.org/10.1097/01.NAJ.0000408181.37017.82

Irissou, E., Guerreiro, B., Aghasibeig, M., Liang, C., Beitari, S., Yue, S., Che, H., Nobari, A., Pouliot, L., Caio, F., Desaulniers, S., Pearson, M., Seow, K., & Boulet, J.-F. (2020). Development and validation of high-performance SARS-CoV-2 antiviral coatings for high-touch surfaces: A joint Canadian project aims to curb the COVID-19 pandemic and future epidemics with cold sprayed, copper-based coatings. *Advanced Materials & Processes, 178*, 40.

Jann, J., Drevelle, O., Chen, X. G., Auclair-Gilbert, M., Soucy, G., Faucheux, N., & Fortier, L. C. (2021). Rapid antibacterial activity of anodized aluminium-based materials impregnated with quaternary ammonium compounds for high-touch surfaces to limit transmission of pathogenic bacteria. *RSC Advances, 11*(60), 38172–38188. https://doi.org/10.1039/d1ra07159a

Kurgat, E. K., Sexton, J. D., Garavito, F., Reynolds, A., Contreras, R. D., Gerba, C. P., Leslie, R. A., Edmonds-Wilson, S. L., & Reynolds, K. A. (2019). Impact of a hygiene intervention on virus spread in an office building. *International Journal of Hygiene and Environmental Health, 222*(3), 479–485. https://doi.org/10.1016/j.ijheh.2019.01.001

Kwok, Y. L., Gralton, J., & McLaws, M. L. (2015). Face touching: A frequent habit that has implications for hand hygiene. *American Journal of Infection Control, 43*(2), 112–114. https://doi.org/10.1016/j.ajic.2014.10.015

Munckhof, W. J., Nimmo, G. R., Schooneveldt, J. M., Schlebusch, S., Stephens, A. J., Williams, G., Huygens, F., & Giffard, P. (2009). Nasal carriage of Staphylococcus aureus, including community-associated methicillin-resistant strains, in Queensland adults. *Clinical Microbiology and Infection : The Official Publication of the European Society of Clinical Microbiology and Infectious Diseases, 15*(2), 149–155. https://doi.org/10.1111/j.1469-0691.2008.02652.x

Nicas, M., & Best, D. (2008). A study quantifying the hand-to-face contact rate and its potential application to predicting respiratory tract infection. *Journal of Occupational and Environmental Hygiene, 5*(6), 347–352. https://doi.org/10.1080/15459620802003896

Pittet, D., Allegranzi, B., Sax, H., Dharan, S., Pessoa-Silva, C. L., Donaldson, L., Boyce, J. M., WHO Global Patient Safety Challenge, & World Alliance for Patient Safety. (2006). Evidence-based model for hand transmission during patient care and the role of improved practices. *The Lancet. Infectious Diseases,* 6(10), 641–652.https://doi.org/10.1016/S1473-3099(06)70600-4

Ploux, L., Ponche, A. & Anselme, K. (2010) Bacteria/Material Interfaces: Role of the material and cell wall properties. *Journal of Adhesion Science and Technology, 24*(13). https://doi.org/10.1163/016942410X511079.

Prakash, J., Cho, J., & Mishra, Y. K. (2022). Photocatalytic TiO_2 nanomaterials as potential antimicrobial and antiviral agents: Scope against blocking the SARS-COV-2 spread. *Micro and Nano Engineering, 14*. https://doi.org/10.1016/j.mne.2021.100100.

Rakowska, P. D., Tiddia, M., Faruqui, N., Bankier, C., Pei, Y., Pollard, A. J., Zhang, J. T., & Gilmore, I. S. (2021). Antiviral surfaces and coatings and their mechanisms of action. *Communications Materials, 2*(1). https://doi.org/10.1038/s43246-021-00153-y.

Saud, Z., Richards, C. A. J., Williams, G., & Stanton, R. J. (2022). Anti-viral organic coatings for high touch surfaces based on smart-release, Cu(2+) containing pigments. *Progress in Organic Coatings, 172*, 107135. https://doi.org/10.1016/j.porgcoat.2022.107135

Sax, H., Allegranzi, B., Uçkay, I., Larson, E., Boyce, J., & Pittet, D. (2007). 'My five moments for hand hygiene': A user-centred design approach to understand, train, monitor and report hand hygiene. *The Journal of Hospital Infection, 67*(1), 9–21. https://doi.org/10.1016/j.jhin.2007.06.004

Schio, A. L., Michels, A. F., Fongaro, G., & Figueroa, C. A. (2021). Trends in the antiviral chemical activity of material surfaces associated with the SARS-CoV-2 outbreak. *Frontiers in Chemical Engineering, 3*. https://doi.org/10.3389/fceng.2021.636075.

Scott, E. (2013). Community-based infections and the potential role of common touch surfaces as vectors for the transmission of infectious agents in home and community settings. *American Journal of Infection Control, 41*(11), 1087–1092. https://doi.org/10.1016/j.ajic.2013.05.014

Sehulster, L., Chinn, R. Y., CDC, & HICPAC (2003). Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR. Recommendations and reports: Morbidity and mortality weekly report. Recommendations and Reports*, *52*(RR-10), 1–42.

Shirvanimoghaddam, K., Akbari, M. K., Yadav, R., Al-Tamimi, A. K., & Naebe, M. (2021). Fight against COVID-19: The case of antiviral surfaces. *APL Materials, 9*(3), 031112. https://doi.org/10.1063/5.0043009

Tleuken, A., Tokazhanov, G., Guney, M., Turkyilmaz, A. & Karaca, F. (2021). Readiness assessment of green building certification systems for residential buildings during pandemics. *Sustainability, 13*(2), 460.https://doi.org/10.3390/su13020460.

Tokazhanov, G., Tleuken, A., Guney, M. & Turkyilmaz, A. (2020). How is COVID-19 experience transforming sustainability requirements of residential buildings ? A review. *Sustainability*, *12*(20). https://doi.org/10.3390/su12208732.

Wertheim, H. F. L., Melles, D. C., Vos, M. C., van Leeuwen, W., van Belkum, A., Verbrugh, H. A. & Nouwen, J. L. (2005). The role of nasal carriage in Staphylococcus aureus infections. *Lancet Infectious Diseases, 5*(12). https://doi.org/10.1016/S1473-3099(05)70295-4.

Whitehead, K. A. & Verran, J. (2007) The effect of surface properties and application method on the retention of Pseudomonas aeruginosa on uncoated and titanium-coated stainless steel. *International Biodeterioration and Biodegradation*, *60*(2). https://doi.org/10.1016/j.ibiod.2006.11.009.

WHO (World Health Organization). (2020). *Cleaning and disinfection of environmental surfaces in the context of COVID-19.* https://apps.who.int/iris/rest/bitstreams/1277966/retrieve.

WHO. (2021). *Considerations for implementing and adjusting public health and social measures in the context of COVID-19.* https://apps.who.int/iris/rest/bitstreams/1351572/retrieve.

Zhang, N., & Li, Y. (2018). Transmission of Influenza A in a student office based on realistic person-to-person contact and surface touch behaviour. *International Journal of Environmental Research and Public Health*, *15*(8). https://doi.org/10.3390/ijerph15081699.

Chapter 9
The Resilience Principles of the Built Environment in Light of Climate Change and the Post-pandemic Era

Osama Omar and Samer El Sayary

Abstract Several challenges and emerging opportunities were already confronting cities at the time of the COVID-19 outbreak, including climate change, digital transformation, sustainable mobility, regenerating degraded areas, redefining public spaces, promoting social inclusion, and integrating the city. Nevertheless, the immediate pandemic crisis has had a significant impact on the lives of people worldwide. Human wellbeing is adversely impacted by cross-infection, both psychologically and physically. Therefore, private and public spaces for living, working, resting, and travelling have changed drastically. During this time of reopening buildings, neighbourhoods, cities, and countries, it is essential to continue to focus on flattening the curves for energy use and CO_2 emissions. The purpose of this chapter is to provide architects or designers with an understanding of the environmental and health issues associated with COVID-19, as well as the high risk of indoor airborne disease transmission. Due to the complexity of the problem and the need for interdisciplinary research, engineering controls, design strategies, and passive architecture techniques should be integrated. This will enable better indoor air quality. Post-coronavirus cities will be built on the foundation of many changes, from the construction materials to the mobility of the citizens. Because neighbourhoods play a crucial role in meeting the needs of their residents under the current pandemic restrictions, they are receiving increasing attention. An important finding in this chapter is the new perspectives for building a healthy environment by combining innovative techniques with passive features of architecture. Meanwhile, this perspective will allow the decision-makers to rethink how they perceive the built environment in light of climate change and the post-pandemic era. To achieve this vision, different disciplines will need to collaborate, and decision-makers will need to participate. The sequence and role of each

O. Omar (✉)
Associate Professor of Architecture, Department of Architecture and Interior Design, College of Engineering, University of Bahrain, Manama, Bahrain
e-mail: oomar@uob.edu.bh

S. El Sayary
Assistant Professor, Faculty of Architecture - Design and Built Environment, Beirut Arab University, Beirut, Lebanon

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_9

player in society will change the entire image of the resilience of built environment across the whole world.

Keywords Resilience · Built environment · Climate change · Post-pandemic · Zero-Energy

1 Introduction

A common disciplinary purpose of public health and city planning is to improve health. According to the US Department of Commerce's Standard City Planning Enabling Act (SCPEA) of 1928 (Chang, 2020), the professional identity of city planning is defined as a guardian of "public interest" the purpose of public planning is to improve the "health, safety, and general welfare" of the people. A public health professional identifies, controls, and prevents illnesses. The physiological metaphors that are often used to describe parks and open spaces—the city's lungs—for example—indicate explicitly the relationship between public health and city planning. Physical planning aims to promote health and prevent occurrences of disease in a city by designing its layout in a manner that promotes health. Theoretical, conceptual, regulatory, and practical elements of urban and regional planning and design emerge from public health crises, such as pandemics, pollution caused by rapid industrialization, congestion caused by urbanization, and loss of green space. During the mid-nineteenth century and around the turn of the twentieth century, sanitary, housing, and social reforms were closely linked to modern city planning, movements that aimed to address issues such as inadequate sanitation, which was itself a pandemic response, and the lack of sunlight and air in crowded tenement housing and dilapidated slums (Banai, 2020).

As a result of the coronavirus pandemic, there has been at least a temporarily reconfigured city life—the relationships between work and residence, leisure, the use of public space, and the safety and security of both public and private transportation—and a promotion of the fundamental equity of access to resources. In a smart planning scenario, the socio-spatial facets of the coronavirus pandemic could not have been anticipated or illustrated this vividly, nor could zoning regulations and comprehensive plans have been applied proactively (Banai, 2013; Kelly, 2010). A better known and more durable pandemic, that of climate change, has a far wider range of tools than the aforementioned planning tool set. Coronavirus pandemics go hand—in—hand with climate change challenges, implying some practical strategies that are commensurate with their dimensions. As it turns out, pandemics make the urban system both more vulnerable and resilient, ironically encouraging people to focus on the durable concepts of urbanism (Banai, 2020).

The majority of people live, work, and play in densely populated environments, which increases their exposure to many pathogens. Airborne transmission is often investigated by infection control specialists as compared to other modes of transmission. Depending on the specific circumstances of exposure, infection can occur via

all routes to varying degrees. All possible exposure pathways must be protected to ensure effective infection control. In addition to being a psychological stress factor, cross-infections are also a health issue, worsening human well-being and affecting the economy. To prevent COVID-19 infection, most countries have improved ventilation, quarantined, and socially distanced themselves from those with the disease (Amoatey et al., 2002; Li et al., 2007; Megahed & Ghoneim, 2020; Morawska et al., 2020; Nishiura et al., 2020; Shakil et al., 2020).

A high correlation was found between COVID-19 infection and air pollution, indicating that the combination of high ambient air pollution levels and the virus posed a risk to the population. There is evidence that virus transmission takes place indoors via airborne transmission, especially in poorly ventilated and crowded environments. There is an increased likelihood of infection in cities with poor air quality, particularly in regions with the lowest Air Quality Index. It seems that air quality has played a critical role in the COVID-19 outbreak (Barcelo, 2020; Conticini et al., 2020; Hassan et al., 2020; Lam, 2020; Setti et al., 2020; Van Doremalen et al., 2020).

The built environment poses a significant threat to human health, which is why it's critical to understand the potential dynamics of infection transmission. It is possible for COVID-19 to be transmitted both directly and indirectly as individuals move through the built environment. Airflow patterns, turbulence, and other sources of turbulence in the indoor environment can cause viral particles to be deposited directly on surfaces or suspended (Cirrincione et al., 2020; Dietz et al., 2020; Horve et al., 2020; Megahed & Ghoneim, 2020; Mohammad Hassan Shakil et al., 2020).

As a result of the bidirectional relationship between humans, insects, pets, and other occupants and their built environments, there is a concern for health. Microbiota shed by humans and tracked back from their everyday lives to built environments can also be re-acquired from their surroundings within built environments. Microorganisms in the built environment are affected by environmental factors. Microorganisms living in the indoor environment have been shown to die when exposed to sunlight (both UV light and visible light). In moist places such as bathrooms and sinks, biofilms can form on common surfaces, which can facilitate the spread of bacteria. Microorganisms survive and spread primarily in household environments. A high level of relative humidity, which increases the number of aerosolized microorganisms and spores, is caused by moisture from daily activities, such as cooking. Microorganisms shed at a different rate according to the indoor air temperature. Human skin squamous cells and other nutrients from humans, insects, pets, and other inhabitants of the built environment can be found on regular household items, such as chairs. Carpets provide microenvironments that can create pockets of high relative humidity. This can promote bacterial growth, prolong their survival, and make them easier to transfer from one person to another. By providing the ability to penetrate the indoor environment through windows, microorganisms from the outside are able to access the indoor environment, contributing to each building's unique microbial makeup. By ventilating through windows, you can reduce potential air contamination by allowing air to exchange. Microorganisms from the human, insect, pet, and

other occupants' personal microbiomes are exchanged with those from the built environment, contributing to a two-way exchange (Horve et al., 2020; Mehdi Alidadi, 2022).

A wide range of social and spatial implications are examined by architects, planners, and built environment professionals in order to generate new patterns and configurations of use (Paital, 2020; Salama, 2020). Infectious disease epidemics, in relation to architectural and urban spaces, are not just about quarantine on the basis of immediate and precautionary measures, but also about design and planning issues and challenges across all types of buildings and urban spaces. as shown in Fig. 1. Despite serious consequences caused by COVID-19, individuals and collectives can review their priorities and choices. Our physical spaces have been redesigned as a response to infectious diseases in most architecture today. Increasing acceptance of distance learning, online shopping, and online entertainment may bring about a change in the design and planning process due to social distancing (Bourouiba, 2020; Chang, 2020).

The whole process and a brief mapping of the chapter methodology can be divided into three phases as described in Fig. 2. Phase 1, focuses on collecting data from various sources, such as Scoups (Elsevier), Springer link, Google Scholar, etc., collating a large sample of studies including papers, books, articles in recognized conference proceedings, and reports. Phase 2 organized the data through reading, filtering, categorizing and summarizing. Phase 3 extracts the information through inductive analysis and graph to arrive at the finding of this study.

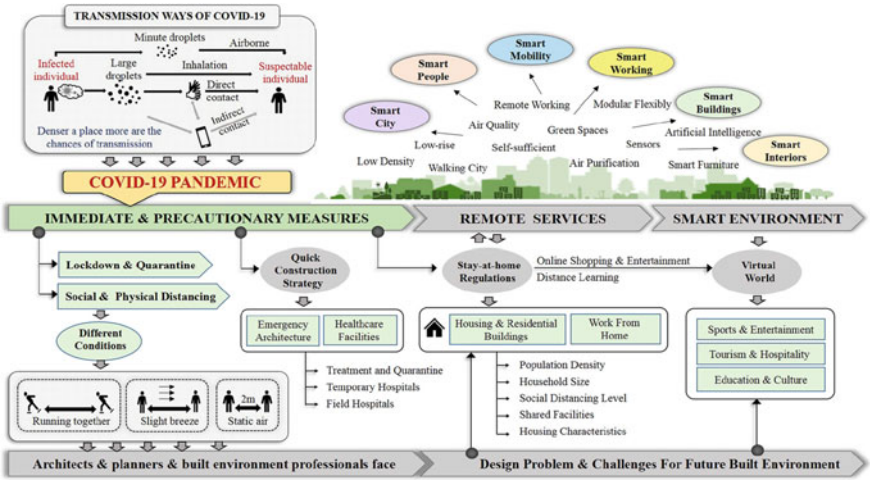


Fig. 1 The relationship between social distancing and lockdown and the variables under investigation (Megahed & Ghoneim, 2020) (License Number: 5496541405220)

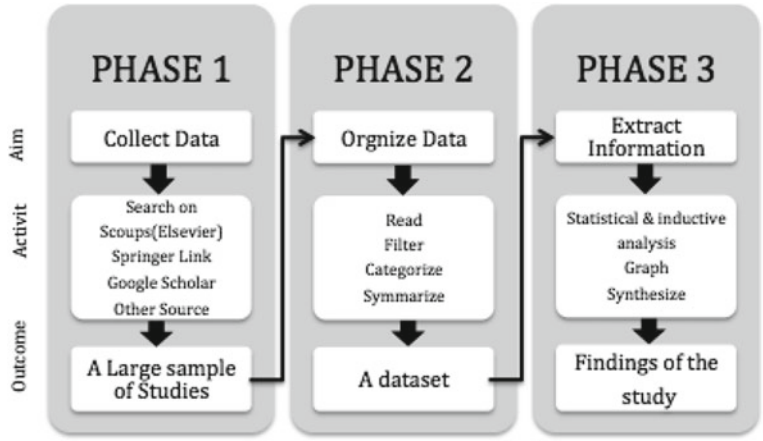


Fig. 2 A brief mapping of the chapter methodology

2 Concept of Resilient Homes

According to findings from Akbari et al. (2021), residents cited quality air and natural light as the most important components of feeling satisfied during COVID-19 quarantine, followed by green landscapes and acoustics. In addition to these environmental factors, spaces and activities (especially the kitchen for the former and gardening for the latter) also play an important role. As a result, residents' satisfaction was strongly influenced by balcony features, green spaces, and outdoor activities. In addition, the study indicated that the availability of balconies, as well as their size, affects the mental health of residents, as homes without balconies have lower levels of mental health than houses with balconies, and homes with balconies with areas of at least five square metres improve their mental health. Furthermore, the study revealed that living in private homes has a beneficial impact on mental health compared to living in multi-storey apartment buildings (Akbari et al., 2021; Elrayies, 2022).

Zarrabi et al. (2020), conducted a study of the population's preferences regarding healthy home indicators in Tehran after epidemics. As well as natural light, air quality, visual and acoustic qualities, and open space, the design of the house and the work space were also found to be important factors. Mental well-being standards are more important than physical health standards, according to the same study. The psychosocial health of apartment occupants is impacted by indoor residential environment quality (IREQ) standards, according to another concurring study. The importance of incorporating mental health into green rating tools such as LEED, BREEAM and other systems was thus highlighted by Zarrabi et al. (2020). These qualitative standards should be mandatory or promoted in the systems categories since they often provide quantitative standards (Elrayies, 2022; Peters, 2020; Zarrabi et al., 2020).

The World Health Organization recommends reducing psychological pressure and improving home environments during home quarantines in order to make homes suitable for the population. By doing so, homes will be able to provide residents with comfort, privacy, and security while protecting their mental and physical health at the same time (Akbari et al., 2021). It has been shown that a healthy home requires adequate ventilation, indoor air quality (IAQ), natural light, sound insulation (especially in multi-story apartment buildings), and adequate air conditioning, heating, and humidity, in order to maintain thermal comfort (Navaratnam et al., 2022; Tokazhanov et al., 2020; Zarrabi et al., 2020), and views, such as (landscapes, and green spaces (Elsaid et al., 2021). Accordingly, health-oriented guidelines for pandemic-resilient homes have been proposed by (Elrayies, 2022), including the following:

- Indoor environmental quality (IEQ): air (natural ventilation, mechanical ventilation, filtration and purification), sunlight/daylight, natural views, domestic green spaces, and acoustics.
- Space: housing type, apartment size, layout type, home advanced technology (home automation, smart kitchen, finishing materials and touchless technologies), shard spaces (lobbies, stairs, elevators, laundry rooms, etc.)
- Household environmental resources management: energy, water, wastewater, solid waste.

Air, sunlight, daylight, plants, water, weather, and landscape are all included in the design framework for pandemic-resilient homes. Nature is incorporated into a biophilic design element. The study also indicates that pandemic-resilient homes can meet sustainability challenges, including the reduction of climate change, the improvement of biodiversity, the reduction and improvement of air pollution, the improvement of thermal comfort, the maximization of food production, and the improvement of the quality of human health. Pandemic-resilient design principles can be used to achieve sustainable architecture and biophilic designs.

The real challenges posed by COVID-19 remain unaddressed despite the short-term interventions that have been adopted in existing homes. The relocation of spaces and deployment of measures such as multi-purpose furniture, eco-friendly sanitary equipment, and smart energy management systems have not been successful despite the adoption of spatial reorganization and smart measures. HVAC systems should be upgraded to incorporate filters and purification techniques, plants should be added and available windows and balconies should be taken advantage of to let nature in. It remains a challenge, especially for housing in unfavourable conditions, to overcome the dilemmas of pre-pandemic homes, including the rapid spread of infectious diseases, self-inadequacy, and mental, psychological, and physical health problems as shown in Fig. 3. Providing sunlight, daylight and, ventilation, and bringing nature indoors are important components of both pandemic-resistant home design (urban spatial organization and site selection) and, architectural design (obtaining the optimal home size to achieve flexibility, privacy, and safety for each family member, determining the right balcony size, modifying the floor plan to accommodate different functions, providing storage space, etc.).

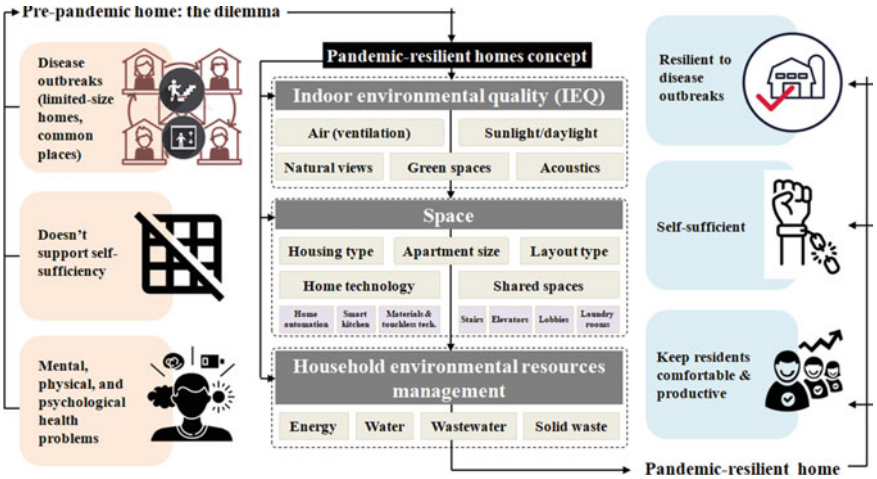


Fig. 3 The concept of pandemic-resilient home (Elrayies, 2022)

In addition to interior design (open layouts allowing for adaptive configurations, modular, collapsible furniture, and multipurpose furniture), the home infrastructure should be equipped with the necessary information and communication technologies, which can create a new lifestyle that is egalitarian, flexible, and efficient both in the aftermath of and during a pandemic. As pandemic shocks become more frequent, homes must become more resilient in order to withstand them. Especially with the widespread adoption of teleworking, the most sought-after housing market in the new scene is that which provides size, luxury, and openness to nature, far away from dense urban centres. A pandemic may have highlighted urban shortcomings in general, but it has enabled a new focus on sustainability and accelerated urban planning. (Elrayies, 2022).

3 Climate-Resilient Strategies and Implications at the City Scale

A question is the beginning of everything! Is building efficiency sufficient to meet energy demands and use renewable energy sources to generate clean energy? The climate crisis has recently prompted the use of terms like "low-carbon city" and, "zero energy cities" which includes low-carbon and zero energy buildings. This claim is simply not true, and today buildings consume an enormous amount of energy and emit a tremendous amount of greenhouse gases (GHG), principally carbon dioxide (CO_2). However, a building constructed from locally sourced materials would use less energy and emit less carbon dioxide compared to one constructed using imported materials (Aboulnaga & Elsharkawy, 2022; El Sayary & Omar, 2017).

In the third quarter of 2021, the energy crisis, in combination with skyrocketing prices and shortages of supply, will forced city leaders and local governments to rethink and develop cities to meet climate neutrality, as well as the impact of COVID-19 and rapid population growth. As a result of the Russian-Ukrainian war in 2022, the crisis has becomes catastrophic not only because oil price have reached around 120.00 US$ since 6 June 2022, but also because global energy and food supplies have been severely disrupted and/or halted (IEA, 2022).

With the growing consciousness about environmental awareness and the depletion of resources in the construction industry, sustainability is becoming more and more important to any building in term of climate mitigation (Liu et al., 2022). Buildings across all types are embracing climate neutrality concepts to reduce and offset CO_2 emissions to a minimum. As long as buildings are not emitting greenhouse gases, they are considered to be "climate-neutral". One of the most important steps in pushing cities to create climate action plans is to encourage global initiatives that aim to enhance climate neutrality and achieve net-zero energy levels. For each city, an action plan identifies specifically what solutions and guidelines are required to mitigate climate change (Grafakos et al., 2002; Höhne et al., 2015).

The concept of climate neutrality refers to the total amount of emissions across embodied energy, operational energy and, industrial processes, as well as non-CO_2 greenhouse gas emissions (Liu et al., 2022). Climate change and the end of the fossil fuel era suggest a period of major, transformative change that will require a rethink of the most fundamental urban systems. Existing communities have a hard time negotiating rapid structural change. It has been found necessary to bring that process from vision to intervention, so that rapid transformation of an existing urban environment can be achieved, so as to develop a new method of urban design—eco-acupuncture—for working with local precincts in metropolitan cities as well as regional towns. Using eco-acupuncture, multiple small interventions in a precinct can shift community perceptions about what is possible, desirable, and permissible, providing a path to a low-carbon future as the community's expectations evolve. Climate change adaptation programmes will be essential no matter what the pace of global action is. A cohesive and mutually reinforcing policy is required for mitigation and adaptation (Ryan, 2013). All urban theories lead to small interventions on different level of urban fabric in order to make positive changes in the face of climate change, which relates to the sustainable development goals (SDGs), particularly SDG number 11 (sustainable cities and communities) as a new vision of future cities.

4 New Resilience Principles of the Built Environment

The proposed design framework was tested in several architectural competitions and awards judged by world—renowned experts, with judging based on principles of health and well being, and the indoor environmental design dealing with several climate zones to enhance the resiliency of the built environment in different geographical locations. As a response to post-pandemic architecture, a decentralized housing model is being developed to express the myriad and vast spectrum of cultural and environmental identities. A large vertical courtyard window acts as a semi-indoor/outdoor space expressing the intangible and hidden values of local societies in a way that is flexible and adaptable to any local culture and changing family needs as shown in Figs. 4 and 5.

A key element of the proposed design is also adaptability and flexibility, as most Middle Eastern families' needs change as time passes and more space is needed. This was solved by creating a multi-purpose space on the ground floor, with large storage units for storing furniture. As a result, the design was able to be used in a variety of ways.

It is premised that Egyptian rural areas suffer from problems with non-healthy housing problems and extreme levels of poverty, and this proposed design aims to address both of these urgent issues while emphasizing social values. The sustainability goals of the United Nations were also incorporated into the design criteria for building a cultural habitat with and for the community.

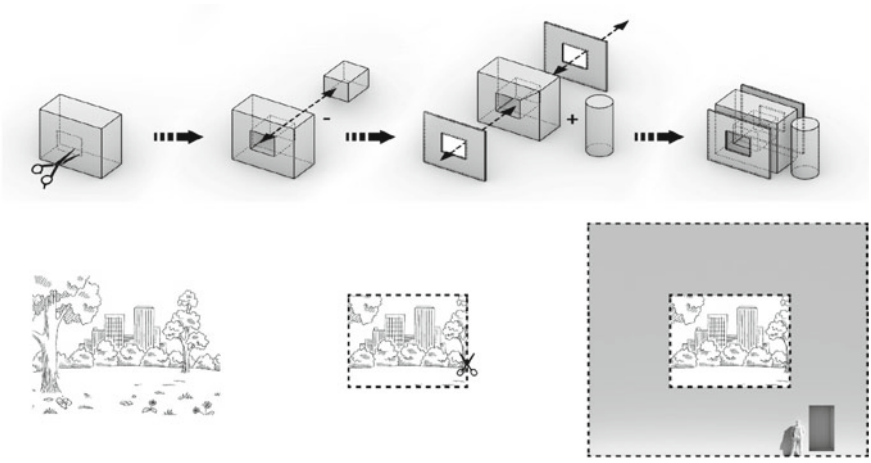


Fig. 4 The concept of the vertical courtyard (design by author. Samer El Sayary)

Fig. 5 Fenaa' project (design by author. Samer El Sayary)

A zero-energy house producing its own water and food was also studied as part of the environmental agenda to push the boundaries of sustainable living. The environmental approach relied on the latest technologies for energy self-sufficiency and renewable resources that were climate-appropriate (Omar, 2020; Samer El Sayary, 2021).

As part of the social approach, interviews and meetings with different social classes were conducted (a human-centered design approach; users were part of the design team) to come up with a design manifesto for an Egyptian contemporary house that reflects Egyptian family aspirations as well as contemporary life-styles, in a perfect square house framing Egyptian views.

Even though the concept design is flexible and adaptable, all calculations for the environment, energy modeling, and CFD simulations were performed in the Giza village quarter area. Using a multi-resource approach, the 50 design criteria combine various Egyptian micro-cultures in a harmony of "**a unity within diversity**" as shown in Figs. 4 and 5 (Table 1).

Table 1 The 50 design criteria for the proposed design

A. Developing our legacy on scale of programmatic study	1. Vertical courtyard with all benefits of traditional courtyard housing and as a healthy open-air container of all social activities in post-pandemic era 2. Reviving and developing the traditional house programme (Maqaad, court, wind-catchers and Majaz, etc.) 3. Flexible plan layout to respond to changing needs of the family 4. Free open plan with modularity concept (column free space)
B. Social core values	5. Human centred design (considering users as members of the design team) 6. Promoting privacy in design as a core Egyptian cultural value 7. Adaptability to social design and life styles 8. Social sustainability for future generations 9. Minimalism life-style (living with less leaving you debt-free and with extra time to work on personal relationships) 10. Answering and fulfilling all functional requirements for places where they both live and work 11. Social equity by enabling access of users to clean water, fresh air and sunlight in their residential units 12. Achieving social sustainability by reviving ancient experiences and building practices 13. Building social connections of many residents in local communities as a by products of a sense of place and connection to the land or "home place"
C. Environmental agenda	14. Passive cooling (two wind catchers) 15. Decreasing carbon foot print by producing its own energy needs 16. Increasing green vegetation rate in urban contexts 17. Using double walls and louvers to decrease sun radiation 18. Decreasing the urban heat island by designing a permeable urban mass for all wind breeze to flow through 19. Each new housing unit will be associated with planting a new tree inside the building
D. Clean water	20. Natural water harnessing (fog nets and rainwater collections)
E. Economic sustainability	21. Eliminating poverty through founding an economic activity inside the house

(continued)

Table 1 (continued)

F. Energy	22. Net zero-energy building (calculations) 23. Considering shades and shadows as a principle of design 24. Using ambient daylight and indirect lights 25. Minimizing energy use by including low energy materials manufacture as well as considering using local building materials to decrease the need for one of the largest energy use - transport
G. Food production	26. Pigeons tower (to ensure both an economic activity and food production) 27. Zero hunger by designing a Food production unit (hydroponics)
H. Urban regeneration	28. Modular design (expanding both vertically and horizontally) with possibility to join more than one unit (vertically and horizontally) 29. Permeable built mass allowing wind breeze to flow through the urban context and decreasing urban heat island 30. Increasing vertical gardens in the city
I. Aesthetical values	31. Adaptation to several Egyptian contexts (unity within diversity principles) 32. Promoting individuality by allowing expression of culture on white facades 33. Framing the natural scenery through the large central window 34. Biophilic design 35. The dynamic effect, where the white facades reflects the changing colours of the day and can absorb any lightscape at night 36. Creating sustainable, successful places that promote wellbeing and trigger innovation and creativity 37. Integrating local pop art in the architecture of the housing unit (night lightscape study)
J. Physical and psychological well being	38. Reducing health risks from pollutants associated with building energy use 39. Designing a healthy environment that achieves the connection with natural phenomena like air and, sunlight, in addition to flora and fauna 40. Creating a stress-free built environment to eliminate pressure causing any social instability 41. Increasing the tolerance of the house users to long stays due to pandemic lockdowns by inserting elements of nature into the built environment

(continued)

Table 1 (continued)

K. Flexibility and adaptability	42. Designing column free interior spaces to be flexible enough to adapt to any everyday changing and growing family need 43. The possibility to construct the house in a place that has no infrastructure yet (total self-sufficiency and off-grid construction) 44. Designing a unit that could be assembled according to numerous urban scenarios based upon the urban density of the location by following the rules of modular design 45. Adapting easily to the local building material available on the site context without major changes in the design
L. Zero waste	46. Elimination of the unnecessary use of resources by limiting the construction materials to only three materials in the whole building 47. A low-tech, durable and high quality design that need minimum maintenance by increasing the whole building cycle with the adaptability to use any local building materials for decreasing the depletion of natural resources 48. Design concept to maximize and re-use any one limited space via many other uses
M. Bio-diversity	49. Protecting the local flora and fauna by replanting any tree that was removed from the site for construction processes inside the vertical courtyard 50. The large, open vertical courtyard window will help the free movement of the seasonal and permanent birds through the urban mass

5 Conclusion

The availability of traditional energy sources, which could become a risk to existence, is one of today's most important global challenges. In 2020, many countries suffered a severe economic crisis, followed by stagnation and the collapse of the energy infrastructure as well as the whole sector due to pandemic lockdowns. Since necessity is the mother of creativity, the energy crisis served as the impetus for both private and public attempts to switch to free renewable energy sources. With the outbreak of the Ukrainian—Russian war in Europe, the issue began to spread to other geographical areas, resulting in even more severe global energy shortages. The need for energy is expanding as humanity's population has reached the eighth billion. New ideas in energy and the built environment have been developed as a

result of this demand. Under the larger rubric of the earth habitation system, ideas like decentralized housing models that are grid independent, zero-energy housing, urban acupuncture in built environments to harness electrical energy from the user's movements, and democratizing energy to all social classes have been developed. This is a promising approach, but one that also needs a legal framework with which to organize it.

References

Aboulnaga, M. & Elsharkawy, M. (2022). Towards Climate Neutrality: Global Perspective and Actions for Net-Zero Buildings to Achieve Climate Change Mitigation and the SDGs. In A. Sayigh (Ed.), *Towards Net Zero Carbon Emissions in the Building Industry* (pp. 373–430). Switzerland: Springer Nature.

Akbari, P. Y., S.-A.; Hosseini, S.-B.; Norouzian-Maleki, S. (2021). Housing and Mental Health during Outbreak of COVID-19. *Journal of Building Engineering, 43*(102919). https://doi.org/10.1016/j.jobe.2021.102919.

Amoatey, P., Omidvarborna, H., Baawain, M., & Al-Mamun, A. (2002). Impact of building ventilation systems and habitual indoor incense burning on SARS-CoV-2 virus transmissions in Middle Eastern countries. *Science of the Total Environment, 733*(139356), 1–3. https://doi.org/10.1016/j.scitotenv.2020.139356

Banai, R. (2013). Plan vs project dilemma revisited: A progress review of urban and regional studies literature. *Urban Studies, 50*(4), 807–824. https://doi.org/10.1177/0042098012458548

Banai, R. (2020). Pandemic and the planning of resilient cities and regions. *Cities, 106*(102929), 1–6. https://doi.org/10.1016/j.cities.2020.102929

Barcelo, D. (2020). An environmental and health perspective for COVID-19 outbreak: Meteorology and air quality influence, sewage epidemiology indicator, hospitals disinfection, drug therapies and recommendations. *Journal of Environmental Chemical Engineering, 8*(104006), 1–4. https://doi.org/10.1016/j.jece.2020.104006

Bourouiba, L. (2020). Turbulent gas clouds and respiratory pathogen emissions: Potential implications for reducing transmission of COVID-19. *JAMA, 323*(18), 1837–1838. https://doi.org/10.1001/jama.2020.4756

Chang, V. (2020). The post-pandemic style. Retrieved from https://slate.com/business/2020/04/coronavirus-architecture-1918-flu-cholera-modernism.html

Cirrincione, L. P., F.; Ledda, C.; Rapisarda, V.; Martorana, D.; Moldovan, R.E.; Theodoridou, K.; Cannizzaro, E. (2020). COVID-19 Pandemic: Prevention and Protection Measures to Be Adopted at the Workplace. *Sustainability, 12*(3603). doi:https://doi.org/10.3390/su12093603

Conticini, E., Frediani, B., & Caro, D. (2020). Can atmospheric pollution be considered a co-factor in extremely high level of SARS-CoV-2 lethality in Northern Italy? *Environmental Pollution, 261*(114465), 1–3. https://doi.org/10.1016/j.envpol.2020.114465

Dietz L, H. P., Coil DA, Fretz M, Eisen JA, Van Den Wymelenberg K. (2020). 2019 Novel Coronavirus (COVID-19) Pandemic: Built Environment Considerations To Reduce Transmission. *mSystems, 5*(2). doi:https://doi.org/10.1128/mSystems.00245-20

El Sayary, S. a. O., Osama (2017). Re- Thinking Courtyard Housing: Development of Traditional Islamic Courthouses into Zero-Energy Buildings. Paper presented at the World Sustainable Built Environment Conference. (2017). *Hong Kong Transforming Our Built Environment through Innovation and Integration: Putting Ideas into Action.* China.

Elrayies, G. M. (2022). Prophylactic Architecture: Formulating the Concept of Pandemic-Resilient Homes. *buildings, 12*(927). doi:https://doi.org/10.3390/buildings12070927

Elsaid, A. M. M., & H.A., Abdelaziz, G.B., Ahmed, M.S. (2021). A critical review of heating, ventilation, and air conditioning (HVAC) systems within the context of a global SARS-CoV-2 epidemic. *Process Saf. Environ, 155*, 230–261.

Grafakos, S., Viero, G., Reckien, D., Trigg, K., Viguie, V., Sudmant, A., & Dawson, R. (2002). Integration of mitigation and adaptation in urban climate change action plans in Europe: A systematic assessment. *Renewable and Sustainable Energy Reviews, 121*(109623). doi:https://doi.org/10.1016/j.rser.2019.109623

Hassan, A., El Mokadem, A., Megahed, N., & Abo Eleinen, O. (2020). Improving outdoor air quality based on building morphology: Numerical investigation. *Frontiers of Architectural Research, 9*(2), 319–334. https://doi.org/10.1016/j.foar.2020.01.001

Höhne, N., Warnecke, C., Day, T., & Röser, F. (2015). *Carbon market mechanisms in future international cooperation on climate change*. Retrieved from

Horve, P. F., Lloyd, S., Mhuireach, G. A., et al. (2020). Building upon current knowledge and techniques of indoor microbiology to construct the next era of theory into microorganisms, health, and the built environment. *Journal of Exposure Science & Environmental Epidemiology, 30*, 219–235. https://doi.org/10.1038/s41370-019-0157-y

IEA. (2022). Oil market report – June 2022 – Analysis – IEA. Retrieved from https://www.iea.org/reports/oil-market-report-june-2022

Kelly, E. D. (2010). *Community planning-An introduction to the comprehensive plan*. Island Press.

Lam, T. (2020). Smart Buildings: How a Virus Might Lead to Healthier Buildings.

Li, Y., Leung, G. M., Tang, J. W., Yang, X., Chao, C. Y. H., Lin, J. Z., et al. (2007). Role of ventilation in airborne transmission of infectious agents in the built environment – a multidisciplinary systematic review. *Indoor Air, 17*(1), 2–18. https://doi.org/10.1111/j.1600-0668.2006.00445.x

Liu, Z., Deng, Z., He, G., Wang, H., Zhang, X., Lin, J., & Liang, X. (2022). Challenges and opportunities for carbon neutrality in China. *Nature Reviews Earth & Environment, 3*(2), 141–155. https://doi.org/10.1038/s43017-021-00244-x

Megahed, N. A., & Ghoneim, E. M. (2020). Indoor Air Quality: Rethinking rules of building design strategies in post-pandemic architecture. *Environmental Research, 193*(110471), 1–9. https://doi.org/10.1016/j.envres.2020.110471

Megahed, N. A., & Ghoneim, E. M. (2020). Antivirus-built environment: Lessons learned from Covid-19 pandemic. *Sustainable cities and society, 61*(102350). doi:https://doi.org/10.1016/j.scs.2020.102350

Mehdi Alidadi, A. S. (2022). Effects of the built environment and human factors on the spread of COVID-19: A systematic literature review. *Science of the Total Environment, 850*(158056). doi:https://doi.org/10.1016/j.scitotenv.2022.158056.

Mohammad Hassan Shakil, Z. H. M., Mashiyat Tasnia, Shahin Sarowar. (2020). COVID-19 and the environment: A critical review and research agenda. *Science of the Total Environment, 745*(141022), 1–9. https://doi.org/10.1016/j.scitotenv.2020.141022.

Morawska, L., Tang, J., Bahnfleth, W., Bluyssen, P., Boerstra, A., Buonanno, G., et al. (2020). How can airborne transmission of COVID-19 indoors be minimised? *Environment International, 142*(105832), 1–7. https://doi.org/10.1016/j.envint.2020.105832

Navaratnam, S. N. K., Selvaranjan, K., Zhang, G.; Mendis, P.; Aye, L. (2022). Designing Post COVID-19 buildings: Approaches for Achieving Healthy Buildings. *buildings, 12*(74). doi:https://doi.org/10.3390/buildings12010074.

Nishiura, H., Oshitani, H., Kobayashi, T., Saito, T., Sunagawa, T., Matsui, T., et al. (2020). Closed environments facilitate secondary transmission of coronavirus disease 2019 (COVID-19). https://doi.org/10.1101/2020.02.28.20029272.

Omar, O. (2020). Near zero-energy buildings in Lebanon: The use of emerging technologies and passive architecture. *Sustainability, 12*(6), 2267. https://doi.org/10.3390/su12062267

Paital, B. (2020). Nurture to nature via COVID-19, a self-regenerating environmental strategy of environment in global context. *The Science of the Total Environment, 729*. https://doi.org/10.1016/j.scitotenv.2020.139088.

Peters, T. H. A. (2020). How our homes impact our health: Using a COVID-19 informed approach to examine urban apartment housing. *International Journal of Architectural Research, 15*(1). https://doi.org/10.1108/ARCH-08-2020-0159.

Ryan, C. (2013). Eco-acupuncture: designing and facilitating pathways for urban transformation, for a resilient low-carbon future. *Journal of Cleaner Production, 50*, 189e199. https://doi.org/10.1016/j.jclepro.2012.11.029.

Salama, A. (2020). Coronavirus questions that will not go away: Interrogating urban and socio-spatial implications of COVID-19 measures. *Emerald Open Research*, 2–14. https://doi.org/10.35241/emeraldopenres.13561.1.

Samer El Sayary, O. O. (2021). Designing a BIM energy-consumption template to calculate and achieve a net-zero-energy house. *Solar Energy, 216*, 315–320. https://doi.org/10.1016/j.solener.2021.01.003

Setti, L., Passarini, F., De Gennaro, G., Barbieri, P., Perrone, M.G., Borelli, M., et al. (2020). SARS-Cov-2RNA found on particulate matter of Bergamo in Northern Italy: First evidence. *Environmental Research, 188*(109754). https://doi.org/10.1016/j.envres.2020.109754.

Shakil, M. H., Munim, Z. H., Tasnia, M., & Sarowar, S. (2020). COVID-19 and the environment: A critical review and research agenda. *Science of the Total Environment, 745*(141022), 1–9. https://doi.org/10.1016/j.scitotenv.2020.141022

Tokazhanov, G. T., A.; Guney, M.; Turkyilmaz, A.; Karaca, F. (2020). How is COVID-19 Experience Transforming Sustainability Requirements of Residential Buildings? A Review. *Sustainability, 12*(8732).

Van Doremalen, N., Bushmaker, T., Morris, D., Holbrook, M.G., Gamble, A., Williamson, B., et al. (2020). Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *The New England Journal of Medicine, 382*(16). https://doi.org/10.1056/NEJMc2004973.

Zarrabi, M. Y., S.-A.; Hosseini, S.-B. (2020). COVID-19 and healthy home preferences: The case of apartment residents in Tehran. *Journal of Building Engineering, 35*(102021). https://doi.org/10.1016/j.jobe.2020.102021.

Chapter 10
Towards Resilient Public Places and Buildings to Pandemics

Ali Cheshmehzangi, Maycon Sedrez, Ayotunde Dawodu, Tim Heath, Tian Li, and Hang Zhao

Abstract This concluding chapter synthesises resilience within public places and building through lessons presented in this book. In fact, human interactions take place on small scales of the built environment, therefore the importance of investigating such conditions. At this level, the effects of the COVID-19 pandemic have also manifested, prompting a reimagining of spatial utilisation. This book gathers experiences and new knowledge that will inform strategic planning and design of our urban environments in the years to come. Moreover, this chapter spotlights key insights that will benefit governments, planners, and designers alike. These insights suggest actions and interventions capable of significantly diminishing the socio-economic and public health impacts that epidemics generate on our societies. In essence, the synthesis of knowledge across these two volumes on resilience vs. pandemics serves as a research-driven response to the task of promoting pandemic-resilient cities and communities. In this sense, achieving the goal of fostering urban sustainability in the face of evolving global challenges.

Keywords Resilience · Pandemics · Public Places · Buildings · Urban Sustainability · Innovation · Management · Cities

A. Cheshmehzangi (✉)
School of Architecture, Qingdao City University, Qingdao, China
e-mail: ali.chesh@qdc.edu.cn

Network for Education and Research On Peace and Sustainability (NERPS), Hiroshima University, Hiroshima, Japan

M. Sedrez
Deakin University, Geelong Waterfront, Australia

A. Dawodu
University of Greenwich, London, UK

T. Heath
University of Nottingham, Nottingham, UK

T. Li · H. Zhao
University of Nottingham Ningbo China, Ningbo, China

A. Cheshmehzangi et al. (eds.), *Resilience vs Pandemics*, Urban Sustainability,
https://doi.org/10.1007/978-981-99-8672-9_10

1 A Summary

In this concluding chapter, we synthesize resilience within public places and building through lessons that have been presented in this book. In fact, human interactions take place on small scales in the built environment, therefore the importance of investigating such condition. At this level, the effects of the COVID-19 pandemic have also manifested, prompting a reimagining of spatial utilisation. This book gathers experiences and new knowledge that will inform strategic planning and design of our urban environments in the years to come. Some of these findings will be useful for future similar (and disruptive) events like what we have experienced during the COVID-19 era (Cheshmehzangi, 2020; Cheshmehzangi et al., 2023a). Here, we extract some insights from each part in the next section.

As presented in volume 1 (Cheshmehzangi et al., 2023b), the book has been organised since mid-2022, when most countries were still under threat from COVID-19 (also known as the COVID-19 era). At that time, many countries were still struggling with the adversities of the pandemic, and their built environment had not fully recovered. However, it was only when spatial interventions matured to the extent that cities and communities were either fully adaptive or used to the conditions of the pandemic. As expressed in the first volume, in the process of fighting the spread of COVID-19, the dynamics of the pandemic can be influenced by different scales of the built environment (Hu et al., 2021; Lak et al., 2021). Previously, we covered them at larger scales, but we note the importance of smaller-scale and detailed interventions in managing the issues and impacts caused by the pandemic. Larger scales, such as regional-level matters (e.g., mobility, closures, etc.), were mainly considered to control the pandemic (Cheshmehzangi et al., 2021), while smaller-scale interventions focused on design-related management. Therefore, in this book, we pay attention to two different spatial levels of the built environment: public places and buildings. Moreover, this chapter highlights critical insights that will benefit governments, planners, and designers alike. These insights suggest actions and interventions capable of significantly diminishing the socio-economic and public health impacts that epidemics generate on our societies. In essence, the synthesis of knowledge across the two volumes holistically serves as a research-driven response to the task of promoting pandemic-resilient cities and communities.

At present, although the pandemic status has changed already, it is possible to say that COVID-19 might still be a threat (Geddes, 2023). Its impacts are still perceptible in various ways, from tangible and worrying economic impacts on society to the longer-term effects on the health and well-being of people that are yet to be discovered. We note that future pandemics are inevitable, and we must start reflecting on the lessons we could/must learn or gain from this so-called once-in-a-century pandemic. An example is China, one of the largest economies in the world, which is still adapting to remove restrictions related to the pandemic. Even after more than nine months of lifting the quarantine measures, China has been extremely cautious in returning to its pre-pandemic travel conditions, inbound and outbound flight numbers, etc. It has to be recorded that at the time we wrote this chapter in September 2023, all personnel

in public services in China still needed to wear facial masks during their work time. Also, the government changed policies only in early September 2023, when they announced inbound international flights to China do not require passengers to take COVID-19 tests before boarding. Such cautious and gradual moves mean the threat is still out there.

Moreover, post-pandemic pressure on society became visible from reports on mental health imbalance (de Vroege & van den Broek, 2023; Łaskawiec et al., 2022) to deficit in learning (Ifeanyi, 2023; Namkung et al., 2022). The pandemic forced people to undergo extreme adaptations in how they live, communicate, and interact with others. Furthermore, this destabilization of health, economy, and society was unprecedented on a global scale and created a tremendous challenge for people to cope. In such perspective, the concept of resilience directly interconnects to the performance of the built environment, generating enough adaptability to accommodate new needs and alleviating pressure on people's life.

Innovations to reduce the impacts of COVID-19 continue to emerge. For instance, a nasal spray vaccine is currently under research and potential development (Chavda et al., 2023). Equally, COVID-19 innovations related to the built environments will also become ubiquitous in future years. We are already witnessing similar adaptive changes to places more local or contextualised before the pandemic. This is because the construction of public places and buildings can take a long period, and resilience towards adaptation will be gradually integrated.

As part of the'Urban Sustainability' book series, we intend to help connect resilience and the built environment within a comprehensive frame and promote more sustainable design, planning, and construction approaches, which ultimately lead to a better quality of life (QoL) for people. The Sustainable Development Goal 11 (i.e., SDG #11)—making cities and human settlements inclusive, safe, resilient, and sustainable (UN Environment Programme, n.d.), composes the book's principles and represents an opportunity to reflect on future development.

In the next section, we follow what we also did in the first volume (Cheshmehzangi et al., 2023b), i.e., to summarise the key findings from the contributing chapters of the book. Here, we extract some prominent points as potential lessons for pandemic-resilient cities and communities from two parts of the book (i.e., at the public place and building spatial levels). Afterward, the last section is a summary covering potential new directions and future research in pandemic management and urban resilience. These are summarised in six key points or checklists, and we hope they conclude the book so that readers are left with ideas, innovative thoughts, questions, and answers for the management, design, and planning of a pandemic-resilient built environment.

2 Extracted Lessons for Pandemic-Resilient Public Places and Buildings

This section extracts some potential lessons from all two parts of the book, mainly for achieving pandemic-resilient cities and communities.

From Part 1, we noted some determinants of urban resilience against pandemics. We noted that the flexibility of public places is crucial to creating a safe and resilient use that benefits its users. The chapters in Part 1 searched the advantages of open green public spaces for mental and physical health. In general, we observed that cities with more open-ventilated green spaces leverage the capacity of people's recovery, relaxation, interaction, and contact with nature. The emergent topic of biophilia contributes to the notion of connecting humans and green spaces, which calms and heals mind and body. This contact with nature has been addressed in architecture and urbanism as nature-based solutions (NBS) to improve urban environments, and one example of NBS to be explored is green roofs. Roofs are typically reserved for technical parts of a building but can perform multiple functions, such as capturing rainwater, generating solar energy, and expanding public places in cities. Where it is difficult to create green roofs (consolidated environments, historic districts, etc.), public buildings become an excellent opportunity for transformation and implementation of nature-based solutions. Even during a lockdown event, proximity to an open green space played a significant role in helping people socialise and have contact with nature. Gardens also represent an option for increasing green spaces, as they can take any form or size. Gardens require care and maintenance, which is another way of mental health therapy. The green surface of public spaces can also extend to facades. Although, in this case, the effects on the user might seem reduced (not possible to walk, sit, or sense), other benefits exist and require further attention from design and planning perspectives. In all existing possibilities of green public places, the adaptability is relevant on a pandemic scenario. We believe future research could expand on this critical topic. As in Volume 1, tactical urbanism is a valuable approach to transforming public places and positively affecting communities. We believe that evidence of the connection between mental health and green spaces has been explored in literature. However, more accurate correlations can emerge from using digital tools and multidisciplinary research methods.

We note from Part 2 that building scale/level resilience is also connected to flexibility and adaptive measures during the pandemic control and management processes (Cheshmehzangi, 2020). For example, several cities observed a shift in working modes as more people got used to working from home. This change was effective and somehow continued to be the common mode of working in some contexts. Large cities had many commercial buildings emptied for other uses, and houses had to be adapted to home offices, meaning that working from home has started to become a way of working during and now after the pandemic era. This abandonment of the Central Business District (CBD) generated an opportunity for increasing housing demands and requirements, some of which led to converting spatial use of housing and communities. As a result, newly developed house plans integrated an office area

as a selling point, creating a demand for sustainable and self-sufficient houses. In addition, the air quality of houses or housing areas has also been targeted during the pandemic, proving that natural ventilation must continue as a primary criterion for architectural design. Another focal point was the cleanness of the environment due to the resistance of COVID-19 to survive for several hours and days. Accessibility and connectivity to amenities were also highlighted as important features in urban planning, leading to fast-forwarding transitions aligned with the concept of a 15-min city and other similar concepts. Factors related to building-level hygiene and regular maintenance became the highlight of larger-scale housing communities, mainly if they had communal spaces or shared areas of interaction. Many considerations are not that building surfaces, particularly if shared, must be frequently cleaned, and hands must be frequently washed. We observed that hand sanitizers became part of building halls and entrances over a short period. Those changes have gradually occurred to be incorporated into social behaviour or described as regulations.

In other examples, issues of density and spatial use were taken into the new level of design and planning guidelines. A populated country like China (now second to India) has quickly adapted to this matter by changing the regulations of having high-rise buildings or limiting the height and density of cities of different tiers. The impacts are also on how spaces are arranged, or building entrances and shared areas are managed. We can see more adaptive measures, yet also more restricted designs, in newly developed projects where interactions are still a significant societal need than a cautionary measure in the post-pandemic era. Nowadays, a more comprehensive focus is on internal building layouts, indicating the possibility of shifting towards healthy buildings and communities. This direction could potentially open up new paradigms and consideration in building renovation strategies, mainly since many existing buildings are not adaptive enough or are not designed to face the adversities of another larger-scale pandemic. One of the other important building-level shifts is related to integrating technologies and digitalised systems in buildings, which was already a slow-paced process via the idea of smart or intelligent buildings. Through such transformative changes, we witness that many public buildings include the use or plan to use robots in some of their secondary operations, such as robots for cleaning, delivery of goods, informing guests or shoppers/travellers, etc. Such changes are expected to expand as technological-based interventions for future building design.

3 New Directions and Future Research

Similar to our first volume on ‘Resilience vs. Pandemics’ (Cheshmehzangi et al., 2023b), in this last section, we summarize some potential new directions and future research in the field of pandemic management and urban resilience. For many stakeholders, applications and strategies are essential, some that could be ubiquitous and some that may require context-specific thinking. In both ways, we believe innovations in the built environment are necessary. We particularly investigate these (new) directions from the perspective of pandemic-resilient strategies, public policies,

tools, implementation, design and planning, architectural interventions, and management of the built environment. The following six directions and future research list summarize some of the suggestions, comments, viewpoints, discussions, ideas, and innovations covered in this book.

(1) **Innovative participatory strategies and public policies**

Participation has been a recurrent theme throughout the various chapters of this book, where citizens' active involvement has enriched the scientific research process with their invaluable perspectives. Finding and selecting volunteers, particularly in the quest for a diverse and representative sample, can be quite challenging and time-consuming. Adapting and refining these participatory methods can increase public engagement, especially when citizens can witness the positive outcomes of their contributions. However, it is essential to acknowledge that during the pandemic, swift and top-down governmental responses often took precedence, limiting the scope for extensive public participation. In this context, we anticipate a growing need for governments to prioritize transparency and make more extensive use of open data accessible. Such data availability would leverage research-based, participatory strategies in the development of public spaces. Artificial Intelligence (AI) can potentially contribute to the simulation of human behaviour; therefore, the convergence of human insight and technological innovation will likely help advance research and design approaches to public spaces.

(2) **The implementation of long-term urban observation and monitoring**

As highlighted in direction 1, the accessibility of data remains confined primarily to specific institutions or government bodies. Promisingly, several cities, including but not limited to New York, São Paulo, and Barcelona, have already unveiled the potential of open data to positive effect. The act of sharing data (significantly) expands the government's capability to analyse, comprehend, and effectively address urban challenges. It also facilitates a comparative analysis of conditions before and after the onset of the pandemic, shedding light on the dynamic shifts in urban landscapes.

(3) **The health and well-being central to pandemic-resilient cities**

The impact of COVID-19 on human health has become indisputably clear. Beyond the enduring health consequences created by the disease itself, it has also ushered in a series of additional effects. Measures like social distancing, quarantines, lockdowns, and the ubiquitous use of face masks have brought the mental well-being of individuals to high levels of stress. This has shown that both homes and public spaces need to evolve towards more flexible and adaptable designs. Furthermore, it has become increasingly apparent that limited social interaction and access to nature diminishes the resilience of our cities and the overall well-being of their inhabitants. Equally important is the need for naturally ventilated buildings, which must be addressed due to reliance on mechanically ventilated spaces.

(4) **Multiple spatial dimensions of the built environment**

We propose the importance of embracing a holistic perspective when assessing the built environment, recognizing it as a multiple spatial complex system encompassing various scales, including the macro-, meso-, and micro-levels. It is within the micro-scale, where human interactions predominantly unfold within public spaces and buildings, that we encounter the potential for multiple challenges to emerge and impact across different scales. As we have previously emphasized in volume 1 (Cheshmehzangi et al., 2023b), there is a pressing need for more in-depth research at the micro-scale, approached through a human-centric perspective, to comprehensively address these interconnected issues.

(5) **Optimization and innovation of existing valid tools**

Public participation emerged as a highly productive research method in social sciences, producing remarkable results. Furthermore, the integration of digital technologies can further enhance the implementation of these methods, fostering more inclusive research interfaces. We anticipate a continued evolution of these participatory methodologies, with volunteers growing increasingly confident in their engagement with research initiatives. Nevertheless, it is imperative for governments to collaborate with researchers in such investigations and respond by making positive changes within the community.

(6) **Flexible, inclusive and equitable architecture, urban design and planning**

Principles of flexibility, inclusivity, and equity within the domains of architecture, urban design, and planning stand as beacons guiding the way toward a more resilient future for our cities and communities. Flexibility in design allows for adaptability in the face of unforeseen challenges created by a pandemic, ensuring that our built environments can evolve in response to changing needs and circumstances. Inclusivity and equality draw us back to the previous discussion in directions 1 to 5, where the scope of participation can expand using digital technologies—and via the government response—to reflect more precisely on community or societal issues. The journey towards flexible, inclusive, and equitable urban environments is an ongoing endeavour, and our commitment to these ideals will shape the cities of tomorrow towards SDG 11.

4 Concluding Remarks

To conclude briefly, we would like to reflect on the green public spaces' capacity to conserve and regenerate human health. For a long time, architects, urban designers, and planners have stressed the need for green cities, not only to alleviate climate

change issues (e.g., heat-island effects, flooding, air quality, etc.) but also to citizens' mental health, well-being, and leisure. This became evident during the pandemic, where compulsory quarantines and lockdown measures limited the individual space. In this sense, flexibility is associated with resilience since public places are more prone to be changed, transformed, or adapted. But still, this requires a planning process to allow such flexible moves to exist. A solution presented in both volumes of this book is tactical urbanism, small-scale interventions that accommodate temporary and creative uses of public space. Another aspect is related to the overall performance of buildings and building quality in terms of airflow, cleanness, and energy efficiency. These critical points remind us of the need for better building renovation, interior design, building services design and integration, and more sustainable and healthy building design strategies than existing business-as-usual scenarios. Such factors also received higher-level attention because people had to spend more time at home or in other indoor spaces.

We reconfirm that this book highlighted the need for citizen participation and collaboration between researchers and government agencies in all scenarios. We believe that, in the future, the boundaries between government, citizens, and science will be blurred, allowing these three agents to associate ideas when it comes to improving the built environment. Thus, there will be more attention on governance to ensure the nexus between multiple actors or stakeholders is enhanced in the best possible way.

Similar to our first volume, the lessons and directions learned from this book can serve as a guideline for researchers, scholars, practitioners, policymakers, planners, and stakeholders. These will be important for promoting new knowledge and applied research and finding innovative pathways to combat or face future pandemics. The two scales of 'public places' and 'buildings', covered in this consequential volume, indicate the complexity of multi-scalar considerations in the built environment. It also suggests that there is no one-solution-for-all scenario, nor is there a way that we can neglect strategies and innovations at the micro scales of the built environment. Thus, we hope the recommendations and comments here will provide readers with new ideas for urban resilience research, help them formulate innovative and resilient strategies and adaptive public policies, and help them rethink and optimize existing urban design, architectural interventions, and planning. After all, the goal is to create pandemic-resilient public places and buildings and finally achieve healthy cities.

References

Chavda, V. P., Baviskar, K. P., Vaghela, D. A., Raut, S. S., & Bedse, A. P. (2023). Nasal sprays for treating COVID-19: A scientific note. *Pharmacological Reports, 75*(2), 249–265. https://doi.org/10.1007/s43440-023-00463-7

Cheshmehzangi, A. (2020). *The City in Need: Urban resilience and city management in disruptive disease outbreak events.* Springer.

Cheshmehzangi, A., Sedrez, M., Ren, J., Kong, D., Shen, Y., Bao, S., Xu, J., Su, Z., & Dawodu, A. (2021). The effect of mobility on the spread of COVID-19 in light of regional differences in the European Union. *Sustainability, 13*(10), 5395. https://doi.org/10.3390/su13105395

Cheshmehzangi, A., Su, Z., Jin, R., Dawodu, A., Sedrez, M., Ardakani, S. P., & Zou, T. (2023a). Space and social distancing in managing and preventing COVID-19 community spread: An overview. *Heliyon, 9*(3), e13879. https://doi.org/10.1016/j.heliyon.2023.e13879

Cheshmehzangi, A., Sedrez, M., Zhao, H., Li, T., Heath, T., & Dawodu, A. (Eds.). (2023b). *Resilience vs. Pandemics: Innovations in Cities and Neighbourhoods*. Springer.

de Vroege, L., & van den Broek, A. (2023). Post-pandemic self-reported mental health of mental healthcare professionals in the Netherlands compared to during the pandemic – an online longitudinal follow-up study. *Frontiers in Public Health, 11*. https://doi.org/10.3389/fpubh.2023.1221427

Geddes, L. (2023). *COVID-19 is no longer a Public Health Emergency of International Concern. Does this mean the pandemic is over?* Gavi, the Vaccine Alliance. Retrieved 25 June, 2023 from https://www.gavi.org/vaccineswork/covid-19-no-longer-public-health-emergency-international-concern-does-mean-pandemic?gclid=EAIaIQobChMIyKfD2v_T_wIVlZuWCh248gU7EAAYASAAEgLV4PD_BwE.

Hu, Z., Wu, Y., Su, M., Xie, L., Zhang, A., Lin, X., & Nie, Y. (2021). Population migration, spread of COVID-19, and epidemic prevention and control: Empirical evidence from China. *BMC Public Health, 21*(1), 529. https://doi.org/10.1186/s12889-021-10605-2

Ifeanyi, F. O. (2023). Barriers to learning linger into post-pandemic for multi-campus institutions in developing nations: A case of the University of The Free State. *Soc Sci Humanit Open, 7*, 1. https://doi.org/10.1016/j.ssaho.2023.100438

Lak, A., Hakimian, P., & Sharifi, A. (2021). An evaluative model for assessing pandemic resilience at the neighborhood level: The case of Tehran. *Sustainable Cities and Society, 75*, 103410. https://doi.org/10.1016/j.scs.2021.103410

Łaskawiec, D., Grajek, M., Szlacheta, P., & Korzonek-Szlacheta, I. (2022). Post-Pandemic Stress Disorder as an Effect of the Epidemiological Situation Related to the COVID-19 Pandemic. *Healthcare, 24*(10), 6. https://doi.org/10.3390/healthcare10060975

Namkung, J.M., Goodrich, J.M., Hebert, M., & Koziol, N. (2022). Impacts of the COVID-19 Pandemic on Student Learning and Opportunity Gaps Across the 2020–2021 School Year: A National Survey of Teachers. *Frontiers in Education, 7*. https://doi.org/10.3389/feduc.2022.921497.

UN Environment Programme. (n.d.). *GOAL 11: Sustainable cities and communities*. UN Environment Programme. Retrieved 25 June, 2023 from https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-11.