



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**HOW CAN ARCHITECTURE MAKE
COMMUNITIES AND URBAN ENVIRONMENTS
MORE RESILIENT TO DISEASE?**

by

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September 2020

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REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 2020	3. REPORT TYPE AND DATES COVERED Master's thesis		
4. TITLE AND SUBTITLE HOW CAN ARCHITECTURE MAKE COMMUNITIES AND URBAN ENVIRONMENTS MORE RESILIENT TO DISEASE?			5. FUNDING NUMBERS	
6. AUTHOR(S) Jeffrey A. Garofalo				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.			12b. DISTRIBUTION CODE A	
13. ABSTRACT (maximum 200 words) The thesis outlines a series of risk factors that will increase the frequency and intensity of disease outbreaks in the years to come. As COVID-19 has shown, an outbreak can occur at any time. Architecture can be an agent to help reduce the risk. By creating spaces that prioritize health-giving attributes—through the circulation of airflow, spatial design, biophilic elements, natural light, and selection of the right building materials—architecture can be built for healing, and to support infection control. In the 19th century, cities like London and New York implemented housing reforms to improve the living conditions in tenements and other dwellings. Back then, the incorporation of light, nature, and airflow into a building's design was seen as a prescription for disease. In recent years, a growing body of research is confirming what the architects and planners from the past deduced from theory and intuition: that the built environment can promote health and well-being, and reduce the public's exposure to such respiratory infections as tuberculosis and COVID-19. Organizations like Mass Design Group and Archive Global have been applying lessons from the past to design spaces of the present with health-giving intent. This thesis examines their work, along with their core strategies. Ultimately, this thesis advances a prescriptive model to shape the built environment to make it healthier and more resilient, and to reimagine how spaces function and operate.				
14. SUBJECT TERMS architecture, building design and health, healing design, disease regulation, resilience, healthy buildings, urban design, built environment and health, indoor air quality and health			15. NUMBER OF PAGES 137	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

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**HOW CAN ARCHITECTURE MAKE COMMUNITIES
AND URBAN ENVIRONMENTS MORE RESILIENT TO DISEASE?**

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Submitted in partial fulfillment of the
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**MASTER OF ARTS IN SECURITY STUDIES
(HOMELAND SECURITY AND DEFENSE)**

from the

**NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

The thesis outlines a series of risk factors that will increase the frequency and intensity of disease outbreaks in the years to come. As COVID-19 has shown, an outbreak can occur at any time. Architecture can be an agent to help reduce the risk. By creating spaces that prioritize health-giving attributes—through the circulation of airflow, spatial design, biophilic elements, natural light, and selection of the right building materials—architecture can be built for healing, and to support infection control. In the 19th century, cities like London and New York implemented housing reforms to improve the living conditions in tenements and other dwellings. Back then, the incorporation of light, nature, and airflow into a building’s design was seen as a prescription for disease. In recent years, a growing body of research is confirming what the architects and planners from the past deduced from theory and intuition: that the built environment can promote health and well-being, and reduce the public’s exposure to such respiratory infections as tuberculosis and COVID-19. Organizations like Mass Design Group and Archive Global have been applying lessons from the past to design spaces of the present with health-giving intent. This thesis examines their work, along with their core strategies. Ultimately, this thesis advances a prescriptive model to shape the built environment to make it healthier and more resilient, and to reimagine how spaces function and operate.

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LIST OF ACRONYMS AND ABBREVIATIONS

AIA	American Institute of Architects
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
CDC	Centers for Disease Control and Prevention
CfAD	Center for Active Design
CPTED	crime prevention through environmental design
EPA	Environmental Protection Agency
GUV	germicidal ultraviolet
IAQ	indoor air quality
LEED	Leadership in Energy and Environmental Design
NAFA	National Air Filtration Association
PM	particulate matter
TB	tuberculosis
UN	United Nations
UV	ultra violet
VOC	volatile organic compound
WHO	World Health Organization

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EXECUTIVE SUMMARY

Today, a storm of forces that will increase the frequency and intensity of infectious disease outbreaks is gathering. According to disease ecologist Peter Daszak, “Pandemics are like terrorist attacks: we know roughly where they originate and what’s responsible for them, but we do not know exactly when the next one will happen.”¹ The world community must take steps to prepare for this threat and to mitigate the forces that are driving individual contagions.² Architecture can play an important role in dampening the risk. The built environment can be shaped to support infection control.

I began working on the thesis a few months before the Coronavirus, which causes the disease COVID-19, broke out. COVID-19 originated in Wuhan, China, an area of 11 million people. By March 2020, the infectious disease had spread to Italy and across Europe, Asia, Canada, and the United States. According to the World Health Organization (WHO), “The disease spreads primarily from person to person through small droplets of saliva or discharge from the nose or mouth, which are expelled when a person with COVID-19 coughs, sneezes, or speaks.”³ The virus is also transmitted via contact with contaminated surfaces. In July 2020, the WHO reported that the virus may be transmitted through the air.⁴ The virus spreads as easily as the seasonal flu and is more lethal. At the time of this writing, there was no vaccine for the disease.

Disease specialists like Daszak contend that economic development that drives people and wildlife together is elevating the risk for diseases like COVID-19.⁵ As parts of Asia, Africa, and India add hundreds of millions of people to densely populated areas over the next 30 years, the risk of similar spillover effects—with pathogens jumping from

¹ Peter Daszak, “We Knew Disease X Was Coming. It’s Here Now,” *New York Times*, February 7, 2020, <https://www.nytimes.com/2020/02/27/opinion/coronavirus-pandemics.html>.

² Daszak.

³ “Q&A on Coronaviruses (COVID-19),” World Health Organization, April 17, 2020, <https://www.who.int/news-room/q-a-detail/q-a-coronaviruses>.

⁴ Linsey C. Marr, “Yes, the Coronavirus Is in the Air,” *New York Times*, July 30, 2020, <https://www.nytimes.com/2020/07/30/opinion/coronavirus-aerosols.html>.

⁵ Daszak, “We Knew Disease X Was Coming.”

animals to humans—will accelerate. As the spread of COVID-19 has shown, a disease outbreak in one corner of the globe has the potential of crossing borders and continents. COVID-19 has also demonstrated how infectious disease thrives in dense urban environments.

Rapid urbanization will create new mega-cities in the developing world that will struggle to provide such basic services as adequate housing, access to clean drinking water, and the removal of waste.⁶ In the past, urban expansion gave rise to unsanitary conditions in slums, which led to the transmission of diseases like cholera, typhoid, tuberculosis, and hepatitis A. In developing countries, unplanned squatter settlements like slums, favelas, and shantytowns will grow at a faster pace than ever before.⁷ These informal urban centers are likely to be overcrowded and dangerous, and breeding grounds for pathogens.

In the 19th century, cities like London and New York enacted building codes to improve the living conditions in tenements and other housing units in each city. In Paris, Baron Haussmann redesigned the city to make it healthier, passing zoning laws that protected light and air in the built environment, and by building new water and sewerage systems. At about the same time, London and New York built massive public works projects to provide clean drinking water.

In recent years, organizations like MASS Design Group and ARCHIVE Global have begun applying some of the lessons from the past to promote architectural design as an important strategy to combat disease around the world.⁸ These organizations have been making design decisions—from the selection of materials to spatial layouts and the circulation of air—to support infection control.⁹ Under the banner of *healing design*, they are employing health-giving strategies to design and retrofit spaces that may be applied to the built environment in the developing world and here at home.

⁶ Jordan Yin, *Urban Planning for Dummies* (Mississauga, ON: Wiley Canada, 2012), Kindle.

⁷ Andrew L. Dannenberg, Howard Frumkin, and Richard J. Jackson, *Making Healthy Places* (Washington, DC: Island Press, 2011), 353.

⁸ “Our Story,” ARCHIVE Global, accessed September 1, 2020, <https://archiveglobal.org/our-story/>.

⁹ MASS Design Group, “Designing Spaces for Infection Control” (fact sheet, MASS Design Group, March 27, 2020), https://massdesigngroup.org/sites/default/files/multiple-file/2020-03/Designing%20Spaces%20for%20Infection%20Control_1.pdf.

In 2020, phrases like *community spread* and *density reduction* have become a part of everyday conversations. Back in February 2017, Bill Gates gave a speech at a security conference in Munich where he warned that pandemics were one of the great challenges of our time.¹⁰ In many respects, his speech presaged the current environment with entire regions of the world on lockdown and with millions of people across the globe under quarantine. Eventually, the spread of COVID-19 will be contained and controlled. But, unfortunately, COVID-19 will not be the last outbreak. It is much more likely that outbreaks will continue to occur, becoming more common and deadly. The world community must be better prepared for the next pandemic and to contain the process that drives individual contagions.¹¹

Specifically, planners and officials need to reimagine how spaces are designed and how people move and interact in them. In March 2020, for example, many grocery stores throughout the country began applying tape and markings on the floor to separate people in line. In the near future, it is likely that visual cues like these will be used in public spaces to ensure social distancing. Today, these types of decisions are being made in some hospitals and firehouses where “hot zones” are separated from “living zones.” (In a firehouse, a “hot zone” is where members don and doff their variously contaminated gear.) In the post-COVID-19 era, these types of decisions will need to be made across all sectors of society.

The thesis examines some of the amplifiers that will increase the risk of outbreaks and pandemics in the years to come. It then explores how architecture may be an agent to help reduce this risk.¹² The thesis prescribes a set of guidelines to help planners, designers, builders, and architects shape urban form—from the design of buildings and public spaces to offices and homes—that support infection control.

¹⁰ Bill Gates, “Speech before the Munich Security Conference” (Munich, Germany, February 17, 2017), <https://www.gatesfoundation.org/Media-Center/Speeches/2017/05/Bill-Gates-Munich-Security-Conference>.

¹¹ Daszak, “We Knew Disease X Was Coming.”

¹² “Role of Architecture in Fighting COVID-19,” MASS Design Group, accessed March 30, 2020, <https://massdesigngroup.org/covidresponse>.

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ACKNOWLEDGMENTS

I would like to thank the FDNY for giving me the opportunity to participate in this program. In particular, I would like to thank Fire Commissioner Dan Nigro, First Deputy Fire Commissioner Laura Kavanagh, Assistant Chief Tom Currao, Assistant Chief Rich Blatus, and First Deputy Commissioner Ed Dolan. I learned a lot of tools, frames, and strategies in this program. My goal is to apply these strategies to help the FDNY prepare for emergencies in the years to come.

I would like to thank Dr. Carolyn Halladay and Dr. Lauren Fernandez for their work reviewing, editing, and organizing my thesis. Their feedback and guidance helped me stay on track, explore new areas, build evidence, and ultimately create a coherent manuscript—to use Dr. Halladay’s words.

I would also like to thank the cohort: 1901/1902. Our cohort represents a lot of backgrounds and disciplines, and this diversity makes it special. From day one, the cohort became a support network to navigate the NPS curriculum, website, assignments, and thesis. I’m incredibly grateful to be part of 1901/1902. Thanks to Beth Windisch, too, for coining the phrase Dr. Wellbe.

Finally, I would like to thank my family for helping me find time to work on course assignments. I wrote part of the thesis at home, at my parents’ in upstate New York, and at my sister’s in March, April, and May when COVID-19 spiked in NYC. I would also like to thank Julie Shahrودي for encouraging me to apply to NPS, for taking care of our boys during the in-residence periods, and for her support throughout the program.

This thesis is dedicated to my two boys: Alex and Andrew.

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I. INTRODUCTION

In the 19th century, a group of reformers, architects, and urban planners began to document the unhealthy conditions in America's cities. In *How the Other Half Lives*, Jacob Riis exposed the unsanitary conditions in New York's slums through photographs and art.¹ The work of Riis and others led to the passage of building codes and regulations that improved health outcomes in tenements and other built environments. The reformers recognized that outbreaks of disease did not stop at a neighborhood's borders. Cities like New York and Boston enacted land-use policies that helped make urban environments more resilient to disease.

History has shown that a disease outbreak can happen at any time. When it does, the spread of disease can be rapid and catastrophic. To put this threat into perspective, more people reportedly died during the Spanish flu pandemic (1918–1920) than in World War II.² A study conducted by the New York City Mayor's Office of Recovery and Resiliency predicts that the next major flu pandemic will occur by 2050.³ In 2015, an outbreak of the Ebola virus in West Africa traveled across the globe to Dallas, Texas, and New York City, as well as to other parts of the country.

In December 2019, the Coronavirus (COVID-19) broke out in Wuhan, China. By March 2020, the virus had spread around the globe. Here in the United States, New York City became the epicenter of the virus. Epidemiologists attribute the spread of the virus in New York to population density and to teeming social interactions that concentrate people

¹ Jimmy Stamp, "Pioneering Social Reformer Jacob Riis Revealed 'How the Other Half Lives' in America," *Smithsonian*, May 27, 2014, <https://www.smithsonianmag.com/history/pioneering-social-reformer-jacob-riis-revealed-how-other-half-lives-america-180951546/>.

² "History of 1918 Flu Pandemic," Centers for Disease Control and Prevention, accessed August 27, 2020, <https://www.cdc.gov/flu/pandemic-resources/1918-commemoration/1918-pandemic-history.htm>.

³ New York City Emergency Management, *NYC's Risk Landscape: A Guide to Hazard Mitigation* (New York: New York City Emergency Management, November 2014), https://www1.nyc.gov/assets/em/downloads/pdf/hazard_mitigation/nycs_risk_landscape_a_guide_to_hazard_mitigation_final.pdf. This guide was developed by New York City Emergency Management in close collaboration with the NYC Department of City Planning and the NYC Mayor's Office of Recovery and Resiliency.

on subways, buses, and trains, in skyscrapers, and public spaces.⁴ Detroit, New Orleans, Philadelphia, Miami, San Antonio, Los Angeles, and Chicago also became hotspots for the virus. As a result, some have argued that pandemics are “anti-urban” because they prey on city dwellers’ impulse to occupy space collectively.⁵

If pandemics and infectious diseases are “anti-urban,” then the risk and potential consequences of pandemics is growing. Urbanization, as well as globalization, and air travel—known to epidemiologists as “amplifiers”—are expected to increase the intensity and frequency of disease outbreaks in the years to come. Rapid urbanization—now and in the near future—will only increase this risk further. Much of this urbanization will take place in developing communities and countries. In some ways, these new population centers will share characteristics with cities from the past. They are likely to be overcrowded and unsanitary. They are likely to be breeding grounds for pathogens.

The world community must come together to manage the pace of growth in the developing world and to support investments in sanitation to sustain it. The world community must treat the developing world as the first line of defense against pandemics. In the post-COVID-19 era, cities throughout the world will also need to reimagine how all urban spaces function, and how people will interact in them.

Today, a growing number of architects and urban planners have embraced the idea that buildings and built environments can have healing power. Organizations like MASS Design Group and ARCHIVE Global are applying lessons from the past to promote architectural design as an important strategy to combat disease around the world.⁶ These organizations design buildings to promote health and well-being through an attention to light, airflow, and a connection to nature. In addition, a growing number of projects identify design flaws in homes, schools, and infrastructure throughout the world—from

⁴ Michael Hooper, “Pandemics and the Future of Urban Density: Michael Hooper on Hygiene, Public Perception and the ‘Urban Penalty,’” Harvard Graduate School of Design, April 13, 2020, <https://www.gsd.harvard.edu/2020/04/have-we-embraced-urban-density-to-our-own-peril-michael-hooper-on-hygiene-public-perception-and-the-urban-penalty-in-a-global-pandemic/>.

⁵ Michael Kimmelman, “Can City Life Survive Coronavirus?,” *New York Times*, March 17, 2020, <https://www.nytimes.com/2020/03/17/world/europe/coronavirus-city-life.html>.

⁶ “Our Story,” ARCHIVE Global, accessed September 1, 2020, <https://archiveglobal.org/our-story/>.

overcrowded conditions to poor lighting and cross-ventilation—to develop interventions to mitigate health risks.⁷

This thesis examines how architecture can make communities and urban environments more resilient to disease and how healing design can support a global war on pandemics. It reviews lessons from the past, along with contemporary approaches, to examine how good building design can reduce the transmission of airborne pathogens, respiratory viruses, and disease. The thesis is prescriptive, recommending the adoption of healing design strategies and solutions to prevent, control, and combat the spread of disease.

A. RESEARCH QUESTION

How can architecture and healing design make communities and urban environments more resilient to disease?

B. LITERATURE REVIEW

The purpose of this literature review is to synthesize prior research on the role of architecture and *healing design* in improving health outcomes and regulating disease. The literature review explores the historical precedents for healing design, along with published works on creating built environments with “health-giving intent.”⁸ The literature review examines the health-giving qualities of light, airflow, and connection to nature in the built environment.

1. The Roots of Healing Design

In “Reconnecting with Our Roots,” Jason Corburn traces the development of the urban planning field to the challenges wrought by mass urbanization in the 19th century.⁹

⁷ Nate Berg, “As Cities Grow More Crammed and Connected, How Will We Discourage the Spread of Disease?,” *Enasia*, July 27, 2016, <https://ensia.com/features/as-cities-grow-diseases-spread-faster-and-urban-design-key/>.

⁸ Christopher Day, *Places of the Soul: Architecture and Environmental Design as a Healing Art*, 3rd ed. (New York: Routledge, 2014), 9.

⁹ Jason Corburn, “Reconnecting with Our Roots,” *Urban Affairs Review* 42 (May 2007): 688, <https://doi.org/10.1177/1078087406296390>.

Corburn writes, “The emergence of urban planning as a profession and academic discipline had its basis in nineteenth century public health initiatives, including tenement housing reforms, the construction of urban water supply and sewerage systems, and the design of parks and playgrounds.”¹⁰ For Corburn, “The common origins of the urban planning and public health professions is also rooted in a view of the city as pathogenic and disorderly, requiring interventions to make urban areas more ‘regular’ and ‘disciplined.’”¹¹ A core goal of the reforms that were implemented during this period was to improve health outcomes in tenements and other built environments. These interventions would later provide the foundation for the modern-day healing design movement.

Many scholars who have written about the state of living conditions during the industrial era share Corburn’s view. In *Urban Health*, the authors link the development of the public health field with the social and physical environment in overcrowded and polluted 19th century cities.¹² The authors assert that these conditions spawned a number of planning and design solutions to improve health through urban form.¹³

Then, as now, these ideas competed with public sentiments that blame the poor for the conditions in slums, shanties, and tenements.¹⁴ These views also presaged the public’s distrust of programs like urban renewal, which left many neighborhoods segregated and isolated.¹⁵ As many scholars have noted, programs like urban renewal have also revealed an undercurrent that opposes the use of land-use ordinances to shape how cities develop. Today, some critics warn that this “architectural philosophy” aims to impose a utopian

¹⁰ Corburn, 688.

¹¹ Corburn, 688.

¹² Sandro Galea, Catherine K. Ettman, and David Vlahov, *Urban Health* (New York: Oxford University Press, 2019).

¹³ Galea, Ettman, and Vlahov.

¹⁴ Institute of Medicine, Committee for the Study of the Future of Public Health, *A History of the Public Health System* (Washington, DC: National Academies Press, 1988), <https://www.ncbi.nlm.nih.gov/books/NBK218224/>.

¹⁵ Emily M. Miltenburg et al., “Consequences of Forced Residential Relocation: Early Impacts of Urban Renewal Strategies on Forced Relocates’ Housing Opportunities and Socioeconomic Outcomes,” *Housing Policy Debate* 28, no. 4 (2018): 609–34, <https://doi.org/10.1080/10511482.2018.1424722>.

ideal on America through heavy-handed regulation.¹⁶ Other critics and scholars warn that these “social engineering” programs are too costly and inefficient.¹⁷

In the 19th century, the industrial revolution brought millions of people to urban areas like London and New York City. At the time, the infrastructure in these cities was not prepared to manage large urban population centers. As environmental conditions worsened, air and water-borne diseases like tuberculosis, cholera, and yellow fever broke out. By 1848, calls to improve these conditions began to ring out. Reformers like Edwin Chadwick showed how poor living conditions directly affected health outcomes and life expectancy.¹⁸ Based on his work, the British Parliament enacted the 1848 Public Health Act in England to “improve the sanitary conditions of the laboring population and to improve the health of the public.”¹⁹ The Public Health Act eventually led the city of London to take steps to combat infectious disease. For example, after John Snow proved that cholera was transmitted through contaminated water, the city of London built a massive sewerage system to protect the city’s drinking water.²⁰

At about the same time, urban centers in America heard similar calls for improving housing conditions. In New York City, Jacob Riis published *How the Other Half Lives*, which exposed the unsanitary conditions in slum neighborhoods like Five Points and the Lower East Side in Manhattan.²¹ In the *Report of the Sanitary Commission of Massachusetts 1850*, Lemuel Shattuck used data to show a link between poor health and substandard sanitation.²² In *The Future of Public Health*, the authors describe this period

¹⁶ Steven Greenhut, “New Urbanism: Same Old Social Engineering,” Foundation for Economic Education, April 1, 2006, <https://fee.org/articles/new-urbanism-same-old-social-engineering/>.

¹⁷ Angela Logomasini, “Green Building: More Expensive and Less Efficient,” Competitive Enterprise Institute, December 17, 2012, <https://cei.org/blog/green-building-more-expensive-and-less-efficient>.

¹⁸ Institute of Medicine, *A History of the Public Health System*.

¹⁹ “The 1848 Public Health Act,” UK Parliament, accessed November 4, 2019, <https://www.parliament.uk/about/living-heritage/transformingsociety/towncountry/towns/tyne-and-wear-case-study/about-the-group/public-administration/the-1848-public-health-act/>.

²⁰ Steven Johnson, *The Ghost Map* (New York: Riverhead, 2006), 87.

²¹ Stamp, “‘How the Other Half Lives’ in America.”

²² Warren Winkelstein, “Lemuel Shattuck: Architect of American Public Health,” *Epidemiology* 19, no. 4 (July 2008): 634, <https://doi.org/10.1097/EDE.0b013e31817307f2>.

as a pivotal turning point—a great social awakening—because a growing consensus began to emerge that policymakers and planners had a shared responsibility to protect the health of the public.²³ Writing for the *American Journal of Public Health*, historian Richard D. Shryock connects this growing consensus to the broader public health movement in America.²⁴

This body of research establishes an intersection between planning and design solutions and public health. The prevailing view is that health-giving design solutions had their origins in the field of urban planning. At the time, most of the energy to improve urban form centered on the construction of sewage and sanitation systems in large urban areas. These same roots would later support health-promoting garden city settlements in American suburbs after World War I. After the war, town planners created suburban areas like Sunnyside Gardens in Queens that were surrounded by greenbelts and greenspaces.²⁵ The field of urban planning also inspired the work of Le Corbusier, who built vertical forms surrounded by parks, playgrounds, and open space.²⁶

The idea that designers and planners could shape urban form to make it more habitable and resilient provides the foundation for the modern healing design movement. Organizations like the American Institute of Architects (AIA) have embraced these principles, advancing the idea that a core goal of architecture is to promote the health and well-being of occupants.²⁷ Under the banner of Design for Wellness, AIA supports design solutions that “put doctors out of business.”²⁸ A host of program areas falls under this banner. For example, New York City runs a program to employ architectural design

²³ Institute of Medicine, *A History of the Public Health System*.

²⁴ Richard H. Shryock, “The Early American Public Health Movement,” *American Journal of Public Health and the Nation’s Health* 27, no. 10 (October 1937): 965–71, <https://doi.org/10.2105/AJPH.27.10.965>.

²⁵ Russell Lopez, *Building American Public Health: Urban Planning, Architecture, and the Quest for Better Health in the United States* (New York: Palgrave Macmillan, 2012), 93, <https://doi.org/10.1057/9781137002440>.

²⁶ Galea, Ettman, and Vlahov, *Urban Health*.

²⁷ “Design for Wellness,” American Institute of Architects, accessed July 31, 2019, <https://www.aia.org/showcases/6082617-design-for-wellness>.

²⁸ American Institute of Architects.

strategies to encourage physical activity to combat obesity and diabetes.²⁹ There is also a growing number of programs that focus on mitigating environmental hazards to reduce non-communicable diseases like stroke, asthma, and heart disease.³⁰ In addition, the Leadership in Energy and Environmental Design (LEED)'s green building certification program has been a catalyst for architects to create spaces that conserve energy.

Many scholars have argued that the public health and urban planning fields began to diverge at the end of the 20th century. In *Toward the Healthy City*, Jason Corburn and Robert Gottlieb make the case for city planning to return to its roots in public health and social justice.³¹ Corburn and Gottlieb's work is largely concerned with restoring health equity in distressed urban neighborhoods. In *Making Healthy Places*, Andrew Dannenberg, Howard Frumkin, and Richard Jackson make the same pitch to reconnect health with planning and design fields.³² The authors back the development of training pathways that integrate public health into architecture, urban planning, and engineering curriculums.³³ Corburn and Gottlieb as well as Dannenberg, Frumkin, and Jackson, among other scholars, believe that the reconnection of the architecture, urban planning, and health disciplines is essential to promoting health equity and reducing chronic diseases like asthma and diabetes. Based on the past, the reintegration of architecture and urban-planning policies and practices into public health will be essential to combat the global spread of disease.

Reconnecting the urban planning and architecture fields with public health will be essential for meeting today's complex global health challenges. Public health risk factors like zoonosis will increase the intensity and frequency of disease outbreaks in the years to

²⁹ City of New York, *Active Design Guidelines: Promoting Physical Activity and Health in Design* (New York: City of New York, 2010), 10.

³⁰ A. Prüss-Ustün et al., *Preventing Disease through Healthy Environments: A Global Assessment of the Burden of Disease from Environmental Risks* (Geneva: World Health Organization, 2016), http://www.who.int/quantifying_ehimpacts/publications/preventing-disease/en/.

³¹ Jason Corburn and Robert Gottlieb, *Toward the Healthy City: People, Places, and the Politics of Urban Planning* (Cambridge, MA: MIT Press, 2009), 2, ProQuest.

³² William Warren Riggs, review of *Making Healthy Places: Designing and Building for Health, Well-Being, and Sustainability*, by Andrew L. Dannenberg, Howard Frumkin, and Richard J. Jackson, *Berkeley Planning Journal* 25, no. 1 (2012), <https://doi.org/10.5070/BP325112307>.

³³ Riggs.

come. Drawing on lessons from the past, planners, policymakers, and architects will have an important role in shaping how cities develop, particularly in the developing world, and in steering the design of built environments to regulate disease. In the post-COVID-19 world, these strategies may help policymakers reimagine how cities and public spaces are designed in order to support infection control.

2. Green Building Design

In *Four Decades of Green Design*, architect David Wright traces the emergence of green building design back to the 1973 oil crisis.³⁴ After the oil embargo, a growing number of architects and students began to think of ways to design buildings that conserve less energy. Under the banner of *passive design*, architects began turning to nature to heat and cool the built environment in order to reduce carbon emissions.³⁵ By harnessing sun, wind, and light, architects are able to design buildings that substitute mechanical systems with power supplied by nature.

Twenty years after the oil crisis, a group of architects came together to devise a rating system to optimize green building design. By 1998, LEED 1.0 was rolled out to test a small number of projects.³⁶ Today, LEED has become a globally recognized rating system, providing a framework for healthy, efficient, and cost-saving green buildings.³⁷ According to the U.S. Green Building Coalition, “The rating system has catalyzed changes in the building industry related to energy, water, waste, indoor environmental quality and more.”³⁸ Data shows that LEED-certification benefits both developers and homeowners in the form of high occupancy rates and property values.³⁹ But critics argue that the design

³⁴ Katherine Flynn, “Four Decades of Green Design,” *Architect Magazine*, December 3, 2019, https://www.architectmagazine.com/aia-architect/four-decades-of-green-design_o.

³⁵ Flynn.

³⁶ “LEED Green Building Certification,” U.S. Green Building Council, accessed November 26, 2019, <https://new.usgbc.org/leed>.

³⁷ U.S. Green Building Council.

³⁸ “USGBC Outlines LEED Positive Vision,” *Architect*, November 21, 2019, https://www.architectmagazine.com/technology/usgbc-outlines-leed-positive-vision_o.

³⁹ Rachel Burger, “What Are the Benefits of LEED Certification?,” *Balance Small Business*, August 9, 2019, <https://www.thebalancesmb.com/what-are-the-benefits-of-leed-certification-845365>.

costs outweigh the benefits, and they point out that the program does not evaluate the performance of a building after construction nor the behavior of occupants consuming energy or water.⁴⁰

The LEED program provides a model with which to evaluate a building design in terms of infection control. Currently, the program tests the design of a building and assigns a rating for indoor air quality.⁴¹ The ratings apply to both commercial spaces like workplaces along with homes. Indoor air quality is important because people spend most of their time indoors. According to the World Health Organization (WHO), more than 4.3 million people die each year from exposure to household air pollutants.⁴² LEED strategies to minimize indoor air toxins and to increase access to fresh airflow are designed to improve an occupants' respiratory health, and to combat such diseases as asthma and chronic obstructive pulmonary disease.⁴³ But critics argue that the LEED standard does not go far enough in restricting the use of harmful compounds in building materials and products that can make people sick.⁴⁴

The LEED program has been a catalyst for building design that considers how construction may impact the environment. But, according to the United Nations (UN), the building and construction sector still accounts for 39 percent of energy and process-related carbon emissions worldwide.⁴⁵ In *How the Architecture Industry is Reacting to Climate Change*, Elizabeth Stamp reports the view that good building design has been confined to a small number of firms and projects. To have greater impact, many architects believe that

⁴⁰ Burger.

⁴¹ U.S. Green Building Council, "LEED Green Building Certification."

⁴² "Indoor Air Pollution," World Health Organization, November 9, 2014, <https://www.who.int/features/qa/indoor-air-pollution/en/>.

⁴³ U.S. Green Building Council, "LEED Green Building Certification."

⁴⁴ Douglas Fischer, "Do Green Building Standards Minimize Human Health Concerns?," *Scientific American*, June 7, 2010, <https://www.scientificamerican.com/article/do-green-building-standards-minimize-health-coconcerns/>.

⁴⁵ Elizabeth Stamp, "How the Architecture Industry Is Reacting to Climate Change," *Architectural Digest*, March 2, 2020, <https://www.architecturaldigest.com/story/climate-change-design-architecture>.

energy efficiency building codes will need to be adopted at the local, state, and international level.⁴⁶

Climate change also affects public health. Studies show that as world temperatures rise, as many as a billion people could be exposed to disease-carrying mosquitoes by the end of the century because of global warming.⁴⁷ Warmer temperatures are likely to increase the risk of mosquito-borne diseases like West Nile, Yellow Fever, and Zika in regions of the world that formerly were too cold for vector-borne pathogens.

Furthermore, climate change is also intertwined with construction and an ecosystem's biodiversity. When a forest is cleared for new construction, greenhouse gas emissions are released. According to conservationists, trees and plants store carbon in their tissue, which makes it even more important to protect them.⁴⁸ New construction also affects the wildlife in a location. People living in a village or city rely upon the local habitat for food and medicine.⁴⁹ According to infectious disease specialists, rapid hunting, breeding, and retailing of wildlife to feed growing population centers increase the risk of zoonotic disease like COVID-19.⁵⁰

3. Design for Wellness

Today, planners and architects are applying design strategies and zoning techniques to help reduce obesity and cardiovascular disease, and to support mental health and well-being. In *Making Healthy Places*, Dannenberg, Frumkin, and Jackson note that, "Mixed land-use, street connectivity, and residential density are the built environment attributes

⁴⁶ Stamp.

⁴⁷ Georgetown University Medical Center, "A Billion People Will Be Newly Exposed to Diseases like Dengue Fever as World Temperatures Rise," ScienceDaily, March 28, 2019, <https://www.sciencedaily.com/releases/2019/03/190328150856.htm>.

⁴⁸ Julie Shaw, "Why Is Biodiversity Important?," Conservation International, November 15, 2018, <https://www.conservation.org/blog/why-is-biodiversity-important>.

⁴⁹ Shaw.

⁵⁰ Peter Daszak, "We Knew Disease X Was Coming. It's Here Now," *New York Times*, February 7, 2020, <https://www.nytimes.com/2020/02/27/opinion/coronavirus-pandemics.html>.

most consistently related to physical activity.”⁵¹ These attributes found a home in the *New Urbanism* movement in the 1980s. Under *New Urbanism*, cities and towns throughout the United States began to use land-use tools to create pedestrian-friendly walkways and zones, along with networks of trails and bike lanes.⁵² During this period, many villages and towns also began to develop Comprehensive Plans, which guided local land-use decisions. These plans became a blueprint for cities and towns to integrate health and wellness activities into local planning processes.⁵³ Many plans also sought to reconnect communities with downtown districts to spur economic, cultural, and recreational activities.

In *Active Design Guidelines: Promoting Physical Activity and Health in Design*, the Bloomberg Administration outlined various strategies to increase physical activity throughout New York City. To prepare this report, the Mayor’s Office brought together planners and designers from several city agencies, including the Department of Design and Construction, the Department of City Planning, the Health Department, and the Department of Transportation to brainstorm ideas and tips on how to shape the built environment to promote movement and activity. The report calls on those “responsible for the planning and construction of buildings, streets, and neighborhoods to design spaces and streets that encourage walking, bicycling, and other forms of active transportation and recreation.”⁵⁴

In 2012, the Bloomberg Administration launched the Center for Active Design (CfAD) to “transform New York City’s groundbreaking program into an international movement.”⁵⁵ Since then, CfAD has become a globally recognized non-profit organization that promotes the design and development of public and private spaces to support health

⁵¹ Andrew L. Dannenberg, Howard Frumkin, and Richard J. Jackson, *Making Healthy Places* (Washington, DC: Island Press, 2011), 36.

⁵² “Principles of Urbanism,” New Urbanism, accessed April 18, 2020, <http://www.newurbanism.org/newurbanism/principles.html>.

⁵³ Dannenberg, Frumkin, and Jackson, *Making Healthy Places*, 275.

⁵⁴ City of New York, *Active Design Guidelines*.

⁵⁵ “About Fitwel: Who We Are,” Fitwel, accessed May 26, 2020, <https://www.fitwel.org/about/>.

and wellness.⁵⁶ As a testament to the success of these programs, the federal government selected CfAD to be the licensed operator of Fitwel, “the world’s leading certification system that optimizes buildings to support health.”⁵⁷ Backed by the U.S. Centers for Disease Control and Prevention and the General Services Administration, Fitwel recognizes building practices that “prioritize wellness within the design, development, and operations of buildings and communities.”⁵⁸ Modeled after CfAD, Fitwel encourages design solutions that support mental health and well-being, and that focus on mitigating chronic conditions like cardiovascular disease and diabetes.

Architects, developers, and/or building managers can register with Fitwell (fees for each project range from \$5,500 to \$12,000 depending on the size of the site) to have new and existing projects considered for certification status.⁵⁹ Fitwell uses a scorecard to evaluate how well an indoor environment supports an employee or occupant’s health, well-being, and productivity.⁶⁰ For example, for an office space, Fitwel’s Certification Team rates an environment’s performance based on several criteria, including: occupant safety, access to healthy foods, level of social engagement, access to outdoor space amenities, access to stairwells, and opportunities for physical activity and movement.⁶¹ According to Fitwel, the certificate of approval is a “signal to employees, residents, and investors that the project integrated wellness strategies into the design and operation of the space.”⁶² Fitwel’s certification program provides a good model to apply to healing design strategies and goals.

⁵⁶ “What Is Active Design?,” Center for Active Design, accessed May 26, 2020, <https://centerforactivedesign.org/WhatIsActiveDesign/>.

⁵⁷ Center for Active Design.

⁵⁸ Fitwel, “Who We Are.”

⁵⁹ Fitwel.

⁶⁰ “What Is the Fitwel Standard?,” Fitwell, accessed September 1, 2020, <https://www.fitwel.org/standard/>.

⁶¹ “What Is Fitwel and Why Should We Care?,” Interior Architects, accessed August 28, 2020, <https://interiorarchitects.com/what-is-fitwel-and-why-should-we-care/>.

⁶² Fitwel, “Who We Are.”

4. Crime Prevention through Environmental Design

In *The Death and Life of Great American Cities*, Jane Jacobs writes that in order for a street to be safe, “There needs to be eyes upon the street, eyes belonging to those we might call the natural proprietors of the street.”⁶³ Jane Jacobs writes about the importance of mixed-use communities and “eyes on the street” as a resident of Greenwich Village in the sixties. Today, her work informs a movement in environmental design that focuses on shaping the built environment to make it safer. This movement is called crime prevention through environmental design (CPTED).

In 2009, the New York City Police Department (NYPD) published a document called, *Engineering Security: Protective Design for High Rise Buildings*. In the report, the NYPD called on high rise building owners to design buildings that can withstand high blast pressures, and to design effective access control systems.⁶⁴ The NYPD’s program is similar to other CPTED strategies that have been implemented around the world. In Australia, CPTED programs focus on reducing crime by the application of lighting, fencing, wayfinding systems, landscaping, building materials, and surveillance of an area from buildings and land use.⁶⁵ Australia’s *Design Out Crime* movement came out of a bill that the Department of Urban Affairs in New South Wales had introduced to Parliament.

The International Crime Prevention Through Environmental Design Association (ICA) describes CPTED as “a multi-disciplinary approach for reducing crime through urban and environmental design and the management and use of built environments.”⁶⁶ According to the ICA, CPTED principles focus on shaping the built environment in a

⁶³ Sarah Goodyear, “A New Way of Understanding ‘Eyes on the Street,’” Bloomberg CityLab, July 22, 2013, <https://www.bloomberg.com/news/articles/2013-07-22/a-new-way-of-understanding-eyes-on-the-street>.

⁶⁴ New York City Police Department, *Engineering Security: Protective Design for High Risk Buildings* (New York: New York City Police Department, 2009), https://www1.nyc.gov/assets/nypd/downloads/pdf/nypd_engineeringsecurity.pdf.

⁶⁵ Western Australian Planning Commission, *Designing Out Crime Planning Guidelines* (Perth: Western Australian Planning Commission, 2006), 1.

⁶⁶ “Home Page,” International Crime Prevention through Environmental Design Association, accessed March 7, 2020, <https://www.cpted.net/>.

systematic way to reduce victimization, and to reduce opportunities for crime and fear of crime.⁶⁷

CPTED strategies treat crime and violence as environmental hazards. Today, architects, city managers, developers, and law enforcement professionals are applying a set of design guidelines to promote safety and security within the built environment. When this work is carried-out in a formal planning process—where these groups come together to evaluate the impact that a project may have on crime in an area—CPTED provides a good working model to apply to support infection control in the built environment.

In sum, elements of Green Building Design, Design for Wellness, and CPTED are components of healing design. For example, the application of natural light in a space supports energy conservation, along with health and well-being. Such wayfinding systems as signage are employed in CPTED programs to move people into safe well-lit areas. In much the same way, wayfinding systems like maps and symbols provide visual cues to guide people through spaces, contributing to a sense of well-being, safety, and security.⁶⁸ Design solutions that promote movement and activity support cardiovascular health. In the same way, spatial strategies can move people away from lobbies and hallways where they are likely to congregate, making them less vulnerable to the spread of disease.⁶⁹ These same strategies can steer people outside for fresh air.

C. RESEARCH DESIGN

In the post-COVID-19 era, the design of the built environment will need to be reimagined. During the 19th century, cities like London, Paris, and New York enacted building codes that transformed how tenements and other dwellings were designed and built. These actions coincided with a broad movement in society to use the levers of power to protect the health of the public. During this period, vaccines to eradicate diseases were

⁶⁷ International Crime Prevention through Environmental Design Association.

⁶⁸ “Wayfinding,” Society for Experiential Graphic Design, accessed April 14, 2020, <https://segd.org/explore/wayfinding>.

⁶⁹ “Role of Architecture in Fighting COVID-19,” MASS Design Group, accessed March 30, 2020, <https://massdesigngroup.org/covidresponse>.

not widely available. Back then, design was seen as an agent of medicine. The spread of COVID-19 has shown that, even today, a disease may take root and spread without a cure. Combatting the outbreak and spread of disease requires a multi-pronged approach. Architecture can play an important role in these efforts.

This thesis surveys prior research on the role of architecture and *healing design* in improving health outcomes and regulating disease. The thesis also reviews the historical precedents for healing design, along with published works on creating built environments with health-giving intent.⁷⁰

The thesis builds a healing design model through case studies. It studies the origin, mission, methodology, and work of two prominent organizations in the healing design movement—Mass Design Group and ARCHIVE Global—to understand how they may inform a broader healing design movement.⁷¹ Data was collected in the form of documents (e.g., articles, journals, books, annual reports), podcasts, videos, observations, plans, and photographs.⁷² The case studies follow this outline:

1. Mission-Driven
2. Research, Build, and Advocacy Cycle
3. Impact-Based Design Methodology
4. Core Design Strategies and Approaches
5. Summary

The thesis develops and recommends the adoption of healing design strategies and solutions to prevent, control, and combat the spread of disease. The thesis develops a healing design model and a set of guidelines for policymakers, planners, and architects to follow. In the aftermath of COVID-19, these tools and guidelines may also inform a

⁷⁰ Day, *Places of the Soul*, 9.

⁷¹ Paul D. Leedy and Jeanne Ellis Ormrod, *Practical Research: Planning and Design*, 12th ed. (New York: Pearson, 2018), 231.

⁷² Leedy and Ormrod, 231.

broad discussion on how to support infection control in buildings, offices, hospitals, schools, and public spaces.

The next chapter will review a group of forces that will increase the frequency and intensity of disease outbreaks. It will then discuss the role that architecture can play in mitigating these threats. Chapter III examines the work of MASS Design Group and ARCHIVE Global. These organizations have been at the forefront of applying healing design strategies into their work. Chapter IV explores the work of researchers, scientists, and architects that are developing and testing prototypes of healthy buildings and environments. It also examines how the built environment may be shaped and adapted to make spaces and infrastructure more resilient in a pandemic. Chapter V surveys the current landscape of the healthy building movement, and presents a new certification program that aims to be pandemic-resistant. It also discusses the role that the urban planning, architecture, and public health fields can play in promoting and validating healthy building standards and practices. Finally, the chapter provides a list of recommendations to shape the built environment to make it healthier.

II. A GLOBAL WAR ON PANDEMICS

In the *Age of the Unthinkable*, Joshua Cooper Ramo argues that in today's age—the specter and speed of risk—from an economic collapse to the spread of disease—has no boundaries, and that the human condition cannot be understood nationally or locally, but only globally.⁷³ In this context, the United States must do more to stop the transmission of disease at its source before it spreads across borders and continents. Recent outbreaks of H1N1, Middle East Respiratory Syndrome (MERS), Severe Acute Respiratory Syndrome (SARS), and now COVID-19 highlight the threat that infectious diseases pose to public health.

This chapter examines a set of forces that will increase the risk of outbreaks and pandemics in the years to come. Specifically, it lays out a set of risk factors that shows that outbreaks like COVID-19 may become the new normal. Each of the risk factors described in the next section are human caused. As such, there is an opportunity to reverse some of these trends or to manage them better.

A. DISEASE RISK FACTORS

This section reviews a set of risk factors that will increase the likelihood of pandemics and disease outbreaks occurring, along with their intensity. Mitigating these risks will likely require a global effort to control the forces that are driving them.⁷⁴

1. Zoonosis

In December 2019, a new respiratory virus called COVID-19 broke out in Wuhan, China. Scientists believe that the virus originated in bats. The virus then passed into another host that was being sold as food in a market in Wuhan. From there, the virus was passed

⁷³ Joshua Cooper Ramo, *The Age of the Unthinkable: Why the New World Disorder Constantly Surprises Us and What We Can Do About It* (New York: Little, Brown and Company, 2009), 10.

⁷⁴ Daszak, “We Knew Disease X Was Coming.”

on to people who ate the food, and the infected people unknowingly spread it to others.⁷⁵ When viruses, bacteria, parasites, and germs pass from animals to humans, the process is called zoonosis.⁷⁶

Zoonosis is a byproduct of urbanization and land-use changes. In developing parts of the world, urban expansion drives deforestation practices to grow crops, and to logging and mining activities to build roads and bridges.⁷⁷ Urbanization has also fueled the farming and breeding of local species, which are sold as food in retail markets. Combined, these activities are increasing the risk that viruses and bacteria may be transmitted from animals to humans.⁷⁸

Scientists attribute the “emergence of new pathogens like COVID-19 to the movement of wild animals toward human settlements.”⁷⁹ In what sounds like the script for a science-fiction film, urbanization is essentially waking-up viruses that had been dormant in wildlife with the viruses then passing from animals to humans. In developing regions of the world, the increasing interactions between wildlife and humans has increased the risk of spillover disease outbreaks. As the developing world becomes more urbanized, these interactions are likely to accelerate.

2. Urbanization

The UN estimates that by 2050 nearly 68 percent of the world’s population will reside in urban areas.⁸⁰ In total, the UN projects that urban areas will add 2.5 billion

⁷⁵ Gabriel Leung, “The Urgent Questions Scientists Are Asking About Coronavirus,” *New York Times*, February 10, 2020, <https://www.nytimes.com/2020/02/10/opinion/coronavirus-china-research.html?referringSource=articleShare&login=email&auth=login-email>.

⁷⁶ “Zoonotic Diseases,” Centers for Disease Control and Prevention, accessed August 28, 2020, <https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html>.

⁷⁷ T. V. Padma, “Deforestation and Disease: How Natural Habitat Destruction Can Fuel Zoonotic Diseases,” Mongabay, April 1, 2020, <https://india.mongabay.com/2020/04/deforestation-and-disease-how-natural-habitat-destruction-can-fuel-zoonotic-diseases/>.

⁷⁸ Padma.

⁷⁹ Padma.

⁸⁰ “68% of the World Population Projected to Live in Urban Areas by 2050, Says UN,” United Nations Department of Economic and Social Affairs, May 16, 2018, <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>.

people.⁸¹ To put this figure in perspective, in just under 30 years, 300 cities equal in size (population) to today's New York City will be created. Nearly 90 percent of this increase will occur in Asia and Africa, and roughly 35 percent of the growth will take place in India, China, and Nigeria.⁸² Mega-cities like Mumbai and Lagos will grow at a faster pace than ever before.⁸³ By 2050, Mumbai will be a city of 40 million people.

This level and pace of urbanization will put a heavy strain on even the most modern, well-built, and prosperous cities in the world. For the developing world, such a level of urban growth will create significant challenges to provide such basic services as adequate housing and access to clean water.⁸⁴ In *Triumph of the City*, economist Edward Glaeser wrote that to meet these challenges, "Urban governments in developing countries must do what the cities of the West did in the nineteenth and early twentieth centuries: provide clean water while safely removing human waste."⁸⁵ If these investments fall short, the global community must fill the void, ensuring that the developing world has sanitation and clean water.

In parts of the world that lack basic sanitation, people live in slums. Today, one in eight people—a billion people in the world—live in slum conditions.⁸⁶ By 2050, the number of people living in slums will double to more than 2 billion.⁸⁷ Data shows that slums are fertile grounds for disease. Today, nearly 1 million people in the developing world die each year from preventable diseases like diarrhea.⁸⁸ Slums in the developing

⁸¹ United Nations Department of Economic and Social Affairs.

⁸² United Nations Department of Economic and Social Affairs.

⁸³ Dannenberg, Frumkin, and Jackson, *Making Healthy Places*, 351.

⁸⁴ Jordan Yin, *Urban Planning for Dummies* (Mississauga, ON: Wiley Canada, 2012), Kindle.

⁸⁵ Edward Glaeser, *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier* (New York: Penguin Books, 2012), loc. 1635 of 6503, Kindle.

⁸⁶ United Nations Habitat, *Slum Almanac 2015/2016* (Nairobi: United Nations, 2015), https://www.worldurbancampaign.org/sites/default/files/subsites/resources/Slum%20Almanac%202015-2016%20EN_16.02_web_0.pdf.

⁸⁷ Richard Florida, "The Amazing Endurance of Slums," Bloomberg CityLab, January 23, 2014, <https://www.bloomberg.com/news/articles/2014-01-23/the-amazing-endurance-of-slums>.

⁸⁸ "Drinking-Water," World Health Organization, June 14, 2019, <https://www.who.int/news-room/fact-sheets/detail/drinking-water>.

world are also breeding grounds for infectious disease like cholera, SARS, and Ebola. As the slum population doubles by 2050, these trends are likely to continue. Unless slum conditions are improved, the number of people who die each from year diseases are likely to grow.

Slums and poor neighborhoods throughout the world are especially vulnerable to disease. The United States has seen COVID-19 ravage poor neighborhoods in New York City and Detroit, preying on people with pre-existing conditions like diabetes and high blood pressure.⁸⁹ Studies show that these conditions are more prevalent in poor neighborhoods.⁹⁰ The disease has also attacked people with asthma who are at greater risk for respiratory infections. Asthma is often prevalent in low-income communities where mold grows in apartments.⁹¹ Tragically, data collected by the Centers for Disease Control and Prevention (CDC) show that African Americans living in poor neighborhoods were more likely than other groups to be hospitalized and to succumb to COVID-19.⁹²

The scale of urbanization that is being projected will make the world community more vulnerable to pandemics and disease outbreaks. In fact, this impact is visible already. When a disease breaks out today, it does not take long for it to spread within and beyond the area of origin. As COVID-19 has demonstrated, viruses also thrive in dense urban environments. Cities bring people together in confined spaces—sharing housing, attending schools, and riding buses, subways, ferries, and transportation systems to get around. These social interactions make residents more vulnerable to outbreaks of respiratory illness and pandemic influenza.⁹³

⁸⁹ Benjamin Wallace-Wells, “Inequality Intensifies the Coronavirus Crisis in Detroit,” *New Yorker*, April 7, 2020, <https://www.newyorker.com/news/news-desk/the-coronavirus-and-inequality-meet-in-detroit>.

⁹⁰ Darrell J. Gaskin et al., “Disparities in Diabetes: The Nexus of Race, Poverty, and Place,” *American Journal of Public Health* 104, no. 11 (November 2014): 2147–55, <https://doi.org/10.2105/AJPH.2013.301420>.

⁹¹ Mimi Kirk, “Why Asthma Is a Housing Issue,” Bloomberg CityLab, June 20, 2017, <https://www.bloomberg.com/news/articles/2017-06-20/the-push-to-hold-landlords-responsible-for-asthma-triggers>.

⁹² David Waldstein, “C.D.C. Releases Early Demographic Snapshot of Worst Coronavirus Cases,” *New York Times*, April 8, 2020, <https://www.nytimes.com/2020/04/08/health/coronavirus-cdc-demographic-study-hospitalizations.html>.

⁹³ New York City Emergency Management, *NYC’s Risk Landscape*, 143.

Michele Acuto, director of the Connected Cities Lab, believes that city managers need to rethink how essential services are provided. Acuto believes that digital tools provide a new means to “relate to city dwellers, engage with core services like healthcare, food delivery and transport, perform jobs, and manage supplies.”⁹⁴ For Acuto and other urban planners, digital tools provide a platform to shift essential services that congregate people into public spaces onto digital devices. These tools and networks can keep people connected and spread out at the same time. As Ian Klaus writes in City Lab, “Digital Infrastructure might be the sanitation of our time.”⁹⁵

3. Globalization

The world is more interconnected than ever before. Policies like the Schengen Agreement in the European Union opened up borders, allowing people and commerce to move freely across the globe. Today, many products are built in stages, with parts made in one location and assembled into finished goods somewhere else. More people cross borders and continents for work or travel than ever before.

I began my research for the thesis by revisiting Stephen King’s fictional book, *The Stand*.⁹⁶ In the novel, a deadly virus sweeps across the globe leaving society on the brink of collapse. On a much smaller level, COVID-19 has revealed how interdependent the world’s economy is and how vulnerable it is to supply shocks.⁹⁷ As reported in *Foreign Affairs*, the pandemic has disrupted supply chains with nations competing with one another for personal protective equipment (PPE), medical supplies, and ventilators.⁹⁸ During this

⁹⁴ Michele Acuto, “Will COVID-19 Make Us Think of Cities Differently?,” *New Cities*, March 20, 2020, <https://newcities.org/the-big-picture-will-covid-19-make-us-think-cities-differently/>.

⁹⁵ Ian Klaus, “Pandemics Are Also an Urban Planning Problem,” *Bloomberg CityLab*, March 6, 2020, <https://www.citylab.com/design/2020/03/coronavirus-urban-planning-global-cities-infectious-disease/607603/>.

⁹⁶ Stephen King, *The Stand* (New York: Anchor, 2008).

⁹⁷ Henry Farrell and Abraham Newman, “Will the Coronavirus End Globalization as We Know It?,” *Foreign Affairs*, March 30, 2020, <https://www.foreignaffairs.com/articles/2020-03-16/will-coronavirus-end-globalization-we-know-it>.

⁹⁸ Farrell and Newman.

crisis, the “Just-in-Time” inventory model has left many hospitals and healthcare workers short of these critical supplies.⁹⁹

Air travel can take a local outbreak in one corner of the globe and transmit it anywhere in the world. On any given day, someone who is unknowingly carrying a disease like the Zika virus or Ebola can get on a plane and land in a densely packed city.¹⁰⁰ Forecasters predict that the number of air travelers will double by 2036 to 7.8 billion with much of this increase coming from the Asia-Pacific region.¹⁰¹ Air travel will continue to accelerate the risk of disease spreading beyond national borders.

As more people move into urban areas, it will become more likely for local shocks—shortages of food, local rivalries, or financial crisis—to spill over into major social upheavals that impact entire regions of the globe.¹⁰² Political instability will make managing disease outbreaks go from challenging to untenable. As an example, the ongoing political and economic crisis in Venezuela reversed gains in controlling such infectious diseases as diphtheria, malaria, measles, and tuberculosis (TB), and increased the risk that these diseases could spread to Brazil, Columbia, and Trinidad and Tobago.¹⁰³

4. Land Use

In *Village of Euclid v. Ambler Realty Company* (1926), the Supreme Court ruled that a zoning ordinance that divided the village into separate districts was a valid exercise of the village’s police power.¹⁰⁴ In *Making Healthy Places*, Andrew L. Dannenberg

⁹⁹ Farrell and Newman.

¹⁰⁰ Berg, “How Will We Discourage the Spread of Disease?”

¹⁰¹ “2036 Forecast Reveals Air Passengers Will Nearly Double to 7.8 Billion,” International Air Transport Association, October 24, 2017, <https://www.iata.org/pressroom/pr/pages/2017-10-24-01.aspx>.

¹⁰² United Nations General Assembly, *Fulfilling the Promise of Globalization: Advancing Sustainable Development in an Interconnected World* (New York: United Nations, 2017), <https://undocs.org/pdf?symbol=en/A/72/301>.

¹⁰³ Daniel R. Coats, “Statement for the Record: Worldwide Threat Assessment of the U.S. Intelligence Community” (Washington, DC: Office of the Director of National Intelligence, 2019), <https://www.dni.gov/index.php/newsroom/congressional-testimonies/item/1947-statement-for-the-record-worldwide-threat-assessment-of-the-us-intelligence-community?tmpl=component&print=1>.

¹⁰⁴ *Village of Euclid v. Ambler Realty Company*, 272 U.S. 365 (1926), <https://www.oyez.org/cases/1900-1940/272us365>.

pointed out that the Court’s decision paved the way for zoning to become a “central technique of city planning.”¹⁰⁵ This technique is used to separate incompatible land uses like industrial and residential uses, and to “promote an orderly pattern of development.”¹⁰⁶

The manner in which zoning is applied can have wide-ranging impacts on a location’s settlement patterns and activities. Many urban planners and scientists believe that pro-growth zoning policies are aiding the spread of disease in developing countries. In *Urbanization and Disease Emergence: Dynamics at the Wildlife-Livestock Human Interface*, James M. Hassell et al. trace the emergence of zoonotic diseases to land-use changes that have exploited natural resources and agriculture in the developing world.¹⁰⁷ These changes, according to infectious disease specialists, are fueled by rapid population growth and density. According to Hassell et al., “Land-use changes, through population-driven anthropogenic influences such as forestry, mining, agriculture, and urban and industrial development, is frequently associated with disease emergence.”¹⁰⁸ The cycle starts with population growth in informal settlements, which leads to the clearing of land and the extraction of resources. These developments increase the number of interactions between people and wildlife. The spike in interactions increases the exposure of humans to vectors of wildlife disease.¹⁰⁹

A group of scientists and urban planners are calling for the reversal of pro-growth policies in the developing world. Organizations like the U.S. Agency for International Development (USAID) are advocating for land-use policies that conserve land and create buffers between human settlements and wildlife. USAID’s Infectious Disease Emergence and Economics of Altered Landscapes (IDEEAL) program investigates how changes to landscapes and the built environment contribute to disease emergence and its associated

¹⁰⁵ Dannenberg, Frumkin, and Jackson, *Making Healthy Places*, 20.

¹⁰⁶ “About Zoning,” New York City Department of City Planning, accessed April 16, 2020, <https://www1.nyc.gov/site/planning/zoning/about-zoning.page>.

¹⁰⁷ James M. Hassell et al., “Urbanization and Disease Emergence: Dynamics at the Wildlife–Livestock–Human Interface,” *Trends in Ecology & Evolution* 32, no. 1 (2017): 55–67, <https://doi.org/10.1016/j.tree.2016.09.012>.

¹⁰⁸ Hassell et al.

¹⁰⁹ Hassell et al.

costs.¹¹⁰ Harking back to the Village of Euclid, organizations like IDEEAL are looking to use zoning techniques to check growth and to balance economic activity with changes in biodiversity and disease emergence.

B. REGULATING DISEASE THROUGH URBAN FORM

With pandemics, the question today is not whether it will happen again; the only question is *when* it will happen again? The world community must take steps today to mitigate this threat. The architecture and urban planning fields can play an important role in building healthy environments and shaping cities to make them more disease resilient. This section highlights some of the design ideas and strategies that can support infection control in the built environment, including biophilic design, maximizing light, air, and cross-ventilation, the treatment of materials and contact surfaces, spatial planning, and spatial literacy (being able to read and understand space).

1. Biophilic Design

Most scholars agree that biophilic design involves incorporating natural materials, light, and vegetation into the built environment.¹¹¹ Some scholars maintain that nature themes exist in the world's oldest built environments, from the Egyptian Sphinx to the Gardens of Babylon.¹¹² Other scholars link the concept to the biologist Edward Wilson, who coined the word *biophilia* in 1964 to describe humans' innate connection with nature.¹¹³ In *Places of the Soul*, Christopher Day describes architecture as a series of decisions and actions that shape human environments and experiences.¹¹⁴ An architect, according to Day, "makes decisions about lighting, gardens, paths, or materials that can

¹¹⁰ "Infectious Disease Emergence and Economics of Altered Landscapes (IDEEAL)," Infectious Disease Emergence and Economics of Altered Landscapes, accessed August 28, 2020, <http://ideeal.eha.io>.

¹¹¹ Stephen R. Kellert, "What Is and Is Not Biophilic Design?," *Metropolis*, October 26, 2015, <https://www.metropolismag.com/architecture/what-is-and-is-not-biophilic-design/>.

¹¹² William Browning, Catherine Ryan, and Joseph Clancy, *14 Patterns of Biophilic Design: Improving Health & Well-Being in the Built Environment* (New York: Terrapin Bright Green, 2014), <https://www.terrapinbrightgreen.com/reports/14-patterns/>.

¹¹³ Browning, Ryan, and Clancy.

¹¹⁴ Day, *Places of the Soul*, 28.

make people feel healthy or unhealthy, inviting or unpleasant—an architect can create environments that are nourishing for human beings.”¹¹⁵ For Day, architects have the power to create spaces that appeal to each of the senses, promoting mental health and well-being.

For Day and other proponents of biophilic design, a core goal of architecture is to create built environments that foster repeated and sustained engagements with nature.¹¹⁶ Many scholars and practitioners believe that biophilic design can “reduce stress, improve cognitive function and creativity, improve our well-being and expedite healing . . . and as the world population continues to urbanize, these qualities are ever more important.”¹¹⁷ In describing the importance of nature in urban form, Frederick Law Olmsted said, “The enjoyment of scenery employs the mind without fatigue and yet exercises it, tranquilizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system.”¹¹⁸ Olmsted may never have used the term “healing design” to describe his work, but his grand parks and playgrounds fit the prescription well.

In the 1980s, psychologists Stephen and Rachel Kaplan coined the phrase *attention restoration theory* to explain nature’s cognitive effects.¹¹⁹ The theory holds that natural settings like mountains, lakes, forests, meadows, and gardens give the brain a break from mentally exhausting tasks.¹²⁰ In many ways, the theory backs Olmsted’s views on nature through empirical evidence. Studies conducted by Hartig, Mang, and Evans found that subjects that spent time in nature performed better on a series of cognitive tasks than a group that had no exposure to nature.¹²¹ A study conducted by Tennessen and Cimprich

¹¹⁵ Day, 21.

¹¹⁶ Kellert, “What Is and Is Not Biophilic Design?”

¹¹⁷ Browning, Ryan, and Clancy, *14 Patterns of Biophilic Design*.

¹¹⁸ Browning, Ryan, and Clancy.

¹¹⁹ Emily Anthes, *The Great Indoors: The Surprising Science of How Buildings Shape Our Behavior, Health, and Happiness* (New York: Farrar, Straus, and Giroux, 2020), loc. 1320 of 4524, Kindle.

¹²⁰ Anthes, loc. 1323.

¹²¹ Stephen Kaplan, “The Restorative Benefits of Nature: Toward an Integrative Framework,” *Journal of Environmental Psychology* 15, no. 3 (September 1995): 169–82, [https://doi.org/10.1016/0272-4944\(95\)90001-2](https://doi.org/10.1016/0272-4944(95)90001-2).

found that students with a view of nature scored higher on a set of tests than students without a view.¹²² In a clinical study of cancer patients, Cimprich found that patients who engaged in such nature-based activities as gardening and walks in nature “showed significantly greater gains on quality of life ratings” than patients who did not engage in these activities.¹²³

When MASS Design Group designed a hospital for a northern province of Rwanda in 2011, it incorporated biophilic elements into the design. They created gardens and shaded seating areas throughout the facility’s campus to encourage patients to spend time outside. In addition to the gardens, MASS created landscaped trails, hills, and pathways with a deliberate circulation strategy to help reduce the transmission of airborne pathogens that cause diseases like TB.¹²⁴ By connecting patients with nature, the planners and architects were also connecting them with fresh air.

2. Light, Air, and Cross-Ventilation

Many scholars and architects associate light and airflow in built environments with health-giving qualities. In 1909, architect Henry Atterbury Smith began work on the Cherokee Apartments on the Upper East Side of Manhattan. Smith’s design for the apartment buildings was inspired by the work of reformers like Jacob Riis and the public health movement. Scholars contend that with the Cherokee Apartments, Smith had designed a new kind of tenement, one with the health and well-being of low-income wage earners in mind.¹²⁵ Virtually every design element that went into the Cherokee Apartments was chosen to maximize light and air inside the apartments and entice residents outside for fresh air.¹²⁶

¹²² Kaplan.

¹²³ Kaplan.

¹²⁴ “The Butaro District Hospital,” MASS Design Group, accessed July 31, 2019, <https://massdesigngroup.org/work/design/butaro-district-hospital>.

¹²⁵ “Cherokee Apartments,” NewYorkitecture, accessed August 28, 2020, <https://www.newyorkitecture.com/cherokee-apartments/>.

¹²⁶ Christopher Gray, “When the Prescription Is Fresh Air,” *New York Times*, January 30, 2014, <https://www.nytimes.com/2014/02/02/realestate/when-the-prescription-is-fresh-air.html>.

Many scholars refer to the Cherokee Apartments as a tuberculosis sanatorium or sanitary tenement.¹²⁷ Smith's design for the Cherokee Apartments came a few years after New York State enacted the Tenement House Act of 1901. This law mandated that every room in a tenement have a window and required light and airflow in every room.¹²⁸ Many scholars attribute the emergence of new building designs that began to appear at the time including "dumbbell tenements"—with their windows facing outside in the front and back and side windows facing airshafts—to the law.¹²⁹ Dumbbell tenements are a good example of planning and design guidelines spurring innovations in the built environment.

In *Places of the Soul*, Christopher Day describes light from two windows on two different walls as "life-giving light, light that is necessary for biological and psychological health, the physiological and aesthetic effects of light are inseparable."¹³⁰ Other scholars have noted how artificial lighting, along with prolonged exposure to poor air quality, can "negatively affect the health and well-being of building occupants."¹³¹ In *Preventing Disease through Healthy Environments*, the World Health Organization links improved airflow and cross-ventilation in occupational settings with reductions in work-related cancer, asthma, and various respiratory diseases.¹³²

Today, organizations like ARCHIVE Global identify design flaws in homes, schools, and infrastructure throughout the world—from overcrowded conditions to poor lighting and cross-ventilation—and develop interventions to mitigate potential health risks.¹³³ ARCHIVE Global is one of a growing number of organizations that is working to combat disease through the design of the built environment.

¹²⁷ "This Upper East Side Co-Op Was a Tuberculosis Sanitarium," Atlas Obscura, accessed November 7, 2019, <http://www.atlasobscura.com/places/cherokee-apartments>.

¹²⁸ Tyler G. Anbinder, *Five Points* (New York: Free Press, 2010), 349.

¹²⁹ Anbinder, 347.

¹³⁰ Day, *Places of the Soul*, 17.

¹³¹ "Health and Architecture in the Home and Office: Air, Light and Sound," Unstudio, accessed November 7, 2019, <http://www.unstudio.com/en/page/10120/health-and-architecture-in-the-home-and-office-air-light-and-sound>.

¹³² Prüss-Ustün et al., *Preventing Disease through Healthy Environments*, 63.

¹³³ ARCHIVE Global, "Our Story."

When Studio Gang was selected to build a new firehouse for Rescue Company 2 in Brooklyn, it made a number of design decisions to connect members with fresh air, and to fill the space with natural light. The firehouse features open air porches, a backyard, and an interior void.¹³⁴ Each decision was made to, “Introduce natural light and fresh air deep into the living quarters, improving the quality of everyday life within the building.”¹³⁵

When architects create spaces that incorporate light and nature into a design, and that bring fresh air into a space, they are building environments that have the power to regulate disease. As an example, well-ventilated spaces can reduce the transmission of respiratory viruses like SARS and COVID-19. As reported in the *American Journal of Infection Control*, studies of the 2002–2003 SARS epidemic “concluded that the relationship between ventilation and indoor airborne transmission of disease was supported by strong and sufficient evidence.”¹³⁶

Ventilation essentially involves replacing contaminated air with fresh air in a built environment. Refreshing indoor air can be done through *passive design*, harnessing wind power to bring fresh air from outside through openings—windows, solar chimneys, and wind towers—in a building’s envelope.¹³⁷ Before the advent of modern heating and cooling systems, buildings were oriented to rely on natural ventilation for airflow, and to control the temperature and thermal environment inside.¹³⁸ A mechanical ventilation system uses ducts and fans to supply clean air and to remove pollutants from a space.¹³⁹

¹³⁴ “Rescue Company 2,” Studio Gang, accessed April 17, 2020, <https://studiogang.com/project/rescue-company-2>.

¹³⁵ Studio Gang, “Rescue Company 2.”

¹³⁶ Luke D. Knibbs et al., “Room Ventilation and the Risk of Airborne Infection Transmission in 3 Health Care Settings within a Large Teaching Hospital,” *American Journal of Infection Control* 39, no. 10 (December 2011): 866–72, <https://doi.org/10.1016/j.ajic.2011.02.014>.

¹³⁷ Andy Walker, “Natural Ventilation,” Whole Building Design Guide, August 2, 2016, <https://www.wbdg.org/resources/natural-ventilation>.

¹³⁸ Justin Davidson, “Is This Harvard Prototype the Greenest Building in America?,” *Intelligencer*, February 25, 2019, <https://nymag.com/intelligencer/2019/02/is-this-harvard-prototype-the-greenest-building-in-america.html>.

¹³⁹ James Atkinson et al., ed., *Concepts and Types of Ventilation, Natural Ventilation for Infection Control in Health-Care Settings* (Geneva: World Health Organization, 2009), <https://www.ncbi.nlm.nih.gov/books/NBK143277/>.

According to Despina Katsikakis of Cushman and Wakefield, most heating, ventilating, and air conditioning (HVAC) systems in commercial properties simply recirculate indoor air, bringing in “little, if any, fresh air.”¹⁴⁰ Katsikakis runs the Occupier Business Performance division at the firm. Instead of bringing in air from outside, Katsikakis says, “They recirculate what’s already inside, which is a mix of carbon dioxide (CO₂) from our exhalations, chemicals that off-gassed from building and decorating materials, and, of course, airborne pathogens.”¹⁴¹

Studies have shown that supplementing mechanical systems with high-efficiency air filters can be an effective strategy to control the airborne transmission of pathogens in schools, offices, and homes.¹⁴² Today, the most commonly used air filter in a building with a mechanical ventilation system is called a MERV 8.¹⁴³ MERV stands for “Minimum Efficiency Reporting Values.” A MERV 8 filter removes approximately 50 percent of particulate matter (PM) in a space.¹⁴⁴ The Environmental Protection Agency (EPA) classifies PM as a group of such indoor pollutants as dust, soot, mold, pollen, and metals that can be inhaled and cause health problems like asthma, bronchitis, and lung disease.¹⁴⁵ During the COVID-19 pandemic, people with chronic conditions like these were more vulnerable to serious complications from the disease. By comparison, a MERV 14 filter removes roughly 95 percent of PM.¹⁴⁶

¹⁴⁰ Mark Wilson, “Our Offices Will Never Be the Same after COVID-19. Here’s What They Could Look Like,” *Fast Company*, April 13, 2020, <https://www.fastcompany.com/90488060/our-offices-will-never-be-the-same-after-covid-19-heres-what-they-could-look-like>.

¹⁴¹ Wilson.

¹⁴² Hua Qian and Xiaohong Zheng, “Ventilation Control for Airborne Transmission of Human Exhaled Bio-Aerosols in Buildings,” *Journal of Thoracic Disease* 10, no. S19 (July 2018): S2295–2304, <https://doi.org/10.21037/jtd.2018.01.24>.

¹⁴³ Joseph G. Allen and John D. Macomber, *Healthy Buildings: How Indoor Spaces Drive Performance and Productivity* (Cambridge, MA: Harvard University Press, 2020), loc. 1957 of 5987, Kindle.

¹⁴⁴ “Understanding MERV: NAFA User’s Guide to ANSI/ASHRAE 52.2,” National Air Filtration Association, October 2018, <https://www.nafahq.org/understanding-merv-nafa-users-guide-to-ansi-ashrae-52-2/>.

¹⁴⁵ “Particulate Matter (PM) Pollution,” Environmental Protection Agency, accessed August 28, 2020, <https://www.epa.gov/pm-pollution/particulate-matter-pm-basics>.

¹⁴⁶ National Air Filtration Association, “Understanding MERV.”

An organization called the National Air Filtration Association (NAFA) ran a series of tests to evaluate how well high-efficiency filters can combat PM. Essentially, NAFA was looking to determine if the benefits of using MERV 14 filters outweighed the additional costs. In its report, NAFA concluded, “While high-efficiency filters are more expensive, that cost is minimal compared to the estimated public health gains associated with using high-efficiency filters in buildings.”¹⁴⁷

In *Healthy Buildings: How Indoor Spaces Drive Performance and Productivity*, Joseph G. Allen and John D. Macomber conducted a series of tests to evaluate the impact of ventilation and indoor air quality on an individual’s creativity and problem-solving skills.¹⁴⁸ During the study, a group of subjects were placed in a controlled office environment and were asked to perform their typical work duties. Each participant received a score based on how well he or she executed tasks, processed information, and managed crisis response communications.¹⁴⁹ What the participants did not know was that Allen and Macomber were changing the air quality in the office by adjusting how much outdoor air was brought into the space. The study showed that ventilation is not simply about bringing outdoor air into a space.¹⁵⁰ What is really important is *how much* air is brought inside.¹⁵¹

According to the EPA, “The rate at which outdoor air replaces indoor air is described as the air exchange rate.”¹⁵² An organization called the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) has established a minimum standard for the air exchange rate. ASHRAE’s “Ventilation for Acceptable Indoor Air Quality” recommends a ventilation rate for commercial buildings of 20 cubic

¹⁴⁷ Tom Ben, Sheng Wang, and Michael S. Waring, “Impact of High-Efficiency Filtration Combined with High Ventilation Rates on Particulate Matter Concentrations in U.S. Offices: Executive Summary” (Middleton, WI: National Air Filtration Association, 2017), 4, <https://www.nafahq.org/wp-content/uploads/NAFA-Exec-Summary-2017.pdf>.

¹⁴⁸ Allen and Macomber, *Healthy Buildings*, loc. 1185.

¹⁴⁹ Allen and Macomber, loc. 1163.

¹⁵⁰ Allen and Macomber, loc. 1163.

¹⁵¹ Allen and Macomber, loc. 1217.

¹⁵² “How Much Ventilation Do I Need in My Home to Improve Indoor Air Quality?,” Environmental Protection Agency, accessed August 28, 2020, <https://www.epa.gov/indoor-air-quality-iaq/how-much-ventilation-do-i-need-my-home-improve-indoor-air-quality>.

feet per minute per person (cfm/person) in order to provide indoor air quality that is “acceptable to human occupants and that minimizes adverse health effects.”¹⁵³ According to Allen and Macomber, nearly every indoor space today—from schools to offices to restaurants—applies the minimum standard for ventilation, which studies show does not deliver healthy air quality.¹⁵⁴ In their study, Allen and Macomber doubled the ventilation rate from the current standard to 40 cfm/person, and found that “in an optimized indoor environment, meaning high ventilation rates and low carbon dioxide, there was a dramatic improvement in cognitive functions and problem-solving abilities.”¹⁵⁵

Writing in the *Harvard Business Review*, Joseph G. Allen also traced the emergence of “sick building syndrome,” a set of such symptoms as headaches, coughing, and chest tightness, to lower ventilation rates.¹⁵⁶ Allen attributes the buildup of indoor air pollutants that trigger these symptoms to a “tightening up of building envelopes and to reducing ventilation rates so buildings wouldn’t have to bring as much fresh air inside.”¹⁵⁷ Starting in the 1970s, the building industry began to trade healthy air for lower energy bills.¹⁵⁸

In *Stale Office Air is Making You Less Productive*, Allen noted that, “Good ventilation has been shown to reduce sick building syndrome symptoms, cut absenteeism, and even reduce infectious disease transmission.”¹⁵⁹ Allen’s findings are consistent with the views of the Lawrence Berkeley National Laboratory on the relationship of ventilation and health. According to the Lab, “Substantially higher rates of respiratory illness (e.g., 50 percent–370 percent) in high-density buildings (barracks, jails, nursing homes, and health care facilities) have been associated with very low ventilation rates, presumably because

¹⁵³ Environmental Protection Agency.

¹⁵⁴ Allen and Macomber, *Healthy Buildings*, loc. 1227.

¹⁵⁵ Allen and Macomber, loc. 1179.

¹⁵⁶ Joseph G. Allen, “Research: Stale Office Air Is Making You Less Productive,” *Harvard Business Review*, March 21, 2017, <https://hbr.org/2017/03/research-stale-office-air-is-making-you-less-productive>.

¹⁵⁷ Allen.

¹⁵⁸ Allen and Macomber, *Healthy Buildings*, loc. 1243.

¹⁵⁹ Allen, “Stale Office Air.”

lower ventilation rates are likely to result in higher airborne concentrations of infectious viruses and bacteria.”¹⁶⁰

In a study published in the *American Journal of Infection Control*, researchers found that increasing ventilation rates in a hospital setting had the effect of reducing the infection risk of influenza, tuberculosis, and rhinovirus.¹⁶¹ For the study, researchers modeled the infection risk for individuals that occupied a lab room for 15 minutes in the presence of an infectious person.¹⁶² They found that for each increase in the outdoor air exchange rate, the risk for infection declined.¹⁶³

Over the long-term, the benefits of bringing in healthy air outweigh the higher energy costs. A study conducted by the National Center for Biotechnology Information (NCBI) found that “doubling the ventilation rate from the ASHRAE minimum cost less than \$40 per person per year in all climate zones.”¹⁶⁴ NCBI is a branch of the National Institutes of Health (NIH). The same study also concluded that doubling the ventilation rate increased employee productivity, reduced absenteeism, and improved health.¹⁶⁵

3. Germicidal Ultraviolet Units

The COVID-19 pandemic has also renewed interest in germicidal ultraviolet (GUV) units to disinfect the air in a space in order to prevent the transmission of airborne infections.¹⁶⁶ The CDC defines this method as “the use of ultraviolet (UV) energy to kill

¹⁶⁰ “Building Ventilation,” Indoor Air Quality Scientific Findings Resource Bank, accessed May 22, 2020, <https://iaqscience.lbl.gov/vent-summary>.

¹⁶¹ Knibbs et al., “Room Ventilation and the Risk of Airborne Infection Transmission.”

¹⁶² Knibbs et al.

¹⁶³ Knibbs et al.

¹⁶⁴ Piers MacNaughton et al., “Economic, Environmental and Health Implications of Enhanced Ventilation in Office Buildings,” *International Journal of Environmental Research and Public Health* 12, no. 11 (2015): 14709–22, <https://doi.org/10.3390/ijerph121114709>.

¹⁶⁵ MacNaughton et al.

¹⁶⁶ Nicholas G. Reed, “The History of Ultraviolet Germicidal Irradiation for Air Disinfection,” *Public Health Reports* 125, no. 1 (2010): 15–27.

or inactivate viral, bacterial, and fungal species.”¹⁶⁷ GUV units can be installed in the ducts of HVAC systems. In the 1980s, GUV lamps were used in hospital settings as a method to control the spread of drug-resistant TB.¹⁶⁸ The effectiveness of the equipment is dependent upon a number of factors, including: “air velocity, humidity, the size of the particles carrying the microorganisms, and the UV system design.”¹⁶⁹ These challenges have limited the use of this technology. Despite these challenges, ultraviolet radiation filters are now being discussed as a method to potentially reduce the transmission of respiratory infections in crowded spaces like transit hubs and schools.¹⁷⁰ GUV units offer the potential to disinfect a room or space and to recirculate clean air. More research is needed to understand better how to operate these units effectively and safely in a variety of settings. Research on GUV units can benefit from public and private partnerships, and from the support of national labs.

In May 2020, the Metropolitan Transportation Authority (MTA) began testing a new technology that uses ultraviolet (UV) light to “zap” and destroy viruses like COVID-19.¹⁷¹ According to the MTA, 150 portable UV devices are now being evaluated in New York City buses, subway cars, and train stations.¹⁷² In a press release, the MTA expressed optimism about the effectiveness of the devices stating, “UV light is an efficient, proven, and effective technology for eliminating viruses, including SARS-CoV-2 that causes COVID-19, from surfaces in MTA’s system.”¹⁷³ The testing is currently occurring during the overnight shutdown hours to disinfect buses and trains. If the testing is successful, the technology would be rolled out across the entire transit system.

¹⁶⁷ S. B. Martin et al., “Ultraviolet Germicidal Irradiation: Current Best Practices,” *Journal of the American Society of Heating, Refrigerating and Air-Conditioning Engineers* 50, no. 8 (August 2008), <https://www.cdc.gov/niosh/nioshtic-2/20034387.html>.

¹⁶⁸ Reed, “The History of Ultraviolet Germicidal Irradiation.”

¹⁶⁹ “Using Ultraviolet Germicidal Lights for Air Cleaning,” Indoor Air Quality Scientific Findings Resource Bank, accessed April 22, 2020, <https://iaqscience.lbl.gov/air-uv>.

¹⁷⁰ Indoor Air Quality Scientific Findings Resource Bank.

¹⁷¹ Stephen Nessen, “The MTA Is Testing Out UV Lights to Zap Coronavirus,” *Gothamist*, May 20, 2020, <https://gothamist.com/news/mta-testing-out-uv-lights-zap-coronavirus>.

¹⁷² Nessen.

¹⁷³ Nessen.

4. The Selection of Building Materials and the Treatment of Surfaces

Architects also make decisions on the selection of building materials that can make spaces healthier. As an example, ARCHIVE Global developed a solution to help stop the spread of disease in a community in Bangladesh. At the time, thousands of children in Bangladesh were dying from parasites and bacteria that were harbored in the dirt floors that were used in their homes.¹⁷⁴ To solve this problem, ARCHIVE Global replaced the mud floors with poured concrete. This simple housing solution helped reduce the transmission of gastrointestinal and parasitic pathogens in Dhaka, Bangladesh.¹⁷⁵ According to ARCHIVE Global, the flooring interventions reduced spending on medications and incidence of diarrheal disease.¹⁷⁶

According to the CDC, “A person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes.”¹⁷⁷ The spread of the virus has architects rethinking what materials they have been using for the treatment of surfaces.¹⁷⁸ In recent years, stainless steel and plastic have been widely used in hospitals, nursing homes, and other settings. These materials are relatively inexpensive and they are easy to clean. Unfortunately, studies have shown that respiratory viruses like COVID-19 can live for several days on stainless steel and plastic surfaces.¹⁷⁹ By comparison, the virus can only live on copper for a few hours.¹⁸⁰

¹⁷⁴ Mark McMenamin, “Poured Concrete Flooring Eliminates Disease in Bangladeshi Homes,” Interior Design, March 14, 2018, <https://www.interiordesign.net/articles/14656-poured-concrete-flooring-eliminates-disease-in-bangladeshi-homes/>.

¹⁷⁵ McMenamin.

¹⁷⁶ “Mud to Mortar,” ARCHIVE Global, accessed September 1, 2020, <https://archiveglobal.org/our-work/mud-to-mortar/>.

¹⁷⁷ “How COVID-19 Spreads,” Centers for Disease Control and Prevention, June 16, 2020, <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html>.

¹⁷⁸ MASS Design Group, “Role of Architecture in Fighting COVID-19.”

¹⁷⁹ “Can COVID-19 Survive on Surfaces?,” WebMD, accessed April 22, 2020, <https://www.webmd.com/lung/how-long-covid-19-lives-on-surfaces>.

¹⁸⁰ “New Coronavirus Stable for Hours on Surfaces,” National Institutes of Health, March 17, 2020, <https://www.nih.gov/news-events/news-releases/new-coronavirus-stable-hours-surfaces>.

According to Bill Keevil, a microbiology researcher at the University of Southampton (UK), what makes copper a “molecular oxygen grenade” for infectious diseases is “copper’s atomic makeup of electrons and ions that seek and destroy the RNA and DNA inside the cell of a bacteria or virus.”¹⁸¹ Copper’s disease-busting efficiency has Keevil and others calling for copper to be used on high-contact surfaces in hospitals, and on poles and turnstiles in transit stations.¹⁸² In 2008, the EPA registered hundreds of copper alloys and surfaces as antimicrobial after efficacy testing and studies.¹⁸³ While copper is more expensive than stainless steel and plastic, experts believe that the material would ultimately save lives and money by reducing the rate of surface contamination in hospitals and long-term care facilities.¹⁸⁴

5. Spatial Design and Literacy

Architects make decisions on how space is organized that may also contribute to infection control. Anyone walking into a fire station today is likely to see the space divided into functional areas like the apparatus bay, a maintenance area to clean and store equipment, administrative offices, training areas, and living quarters.¹⁸⁵ These zones triage activities and sequence the flow of members through the station. When firefighters return from a call, they enter into a designated “Red Zone” where their turn-out gear is removed, washed, and stored. They proceed from the “Red Zone” into a “Yellow Zone” to shower and remove contaminants from their body.¹⁸⁶ After passing through the “Yellow Zone,” they may enter the “Green Zone,” which includes the kitchen and living quarters. As they

¹⁸¹ Jim Morrison, “Copper’s Virus-Killing Powers Were Known Even to the Ancients,” *Smithsonian*, April 14, 2020, <https://www.smithsonianmag.com/science-nature/copper-virus-kill-180974655/>.

¹⁸² Shayla Love, “Copper Destroys Viruses and Bacteria. Why Isn’t It Everywhere?,” *VICE*, March 18, 2020, https://www.vice.com/en_us/article/xgqkyw/copper-destroys-viruses-and-bacteria-why-isnt-it-everywhere.

¹⁸³ “EPA Approves Registration of Antimicrobial Copper Alloys,” *Infection Control Today*, March 25, 2008, <https://www.infectioncontroltoday.com/view/epa-approves-registration-antimicrobial-copper-alloys>.

¹⁸⁴ Morrison, “Copper’s Virus-Killing Powers.”

¹⁸⁵ Morrison.

¹⁸⁶ Matt Bickel, John McNamara, and Jake Wollensak, *From Red to Green: How a Zoned Approach to Fire Station Design Supports Firefighter Health and Safety* (St. Paul: Wold, 2018), https://www.woldae.com/wp-content/uploads/2018/05/Wold_WhitePaper_FireStation_Final-Draft.pdf.

move from the “Red Zone” to the “Green Zone,” they are moving from zones with higher contamination to zones of low to no contamination.”¹⁸⁷ This model can be replicated in a number of settings, for example, hospitals and long-term care facilities. Alyssa Giacobbe points out in *Architectural Digest* that the emergency department is “meant for staging and triage, but today features a place designated for waiting, which is precisely where you want to avoid having highly contagious people.”¹⁸⁸

The COVID-19 pandemic has spurred a lot of discussion about what the office of the future may look like. In a conversation with filmmaker Gary Hustwit, interior designer Primo Orpilla foresees an industry-wide reassessment of the open-floor layout concept.¹⁸⁹ In recent years, open-floor layouts have become very common, growing in popularity from the tech and creative industries to city government. However, the attributes that made these open-floor layouts popular—shared workspaces and communal areas like coffee bars and kitchens—also made them breeding grounds for the spread of the virus.¹⁹⁰ The open-floor layout will likely be reconfigured, bringing back offices and cubicles, along with partitions and walls to enforce social distancing. Cushman and Wakefield have already developed a concept they are calling the *Six Feet Office*, which uses wayfinding systems like circles and arrows to keep each workspace at least six feet apart.¹⁹¹ Visually, the layout conjures up an image of workspaces as mini-islands, separated by barriers and trails to move around in.

¹⁸⁷ Bickel, McNamara, and Wollensak.

¹⁸⁸ Alyssa Giacobbe, “How the COVID-19 Pandemic Will Change the Built Environment,” *Architectural Digest*, March 18, 2020, <https://www.architecturaldigest.com/story/covid-19-design>.

¹⁸⁹ Gary Hustwit (@gary_hustwit), “The Future of the Office,” Twitter, April 17, 2020, 5:33 p.m., https://twitter.com/gary_hustwit/status/1251277573671333889.

¹⁹⁰ Konrad Putzier, “Your Open-Floor Office Could Help Spread Coronavirus,” *Wall Street Journal*, March 10, 2020, <https://www.wsj.com/articles/your-open-floor-collaborative-office-could-help-spread-coronavirus-11583784275>.

¹⁹¹ Wilson, “Our Offices Will Never Be the Same.”

III. ARCHITECTURE AND HEALING DESIGN

This chapter examines the work of two organizations on the forefront of healing design: MASS Design Group and ARCHIVE Global. Both organizations have fully integrated healing design strategies into their practice. Both groups develop design solutions that may be scaled and replicated to support healing. Furthermore, they both prioritize health-giving attributes into all phases of their work. By studying these organizations, a prescriptive model can be developed to shape urban form to promote health and well-being.

A. CASE STUDY: MASS DESIGN GROUP

For more than a decade, MASS Design Group has prioritized health-promoting strategies into their work. The organization has also been an advocate for the healthy building movement, and for sustainable practices in design. In “Designing to Survive,” Phillip Kennicott notes how many of the group’s projects use “mostly low-tech means, including natural ventilation, high ceilings, external corridors, and low-speed fans to minimize the transmission of airborne diseases.”¹⁹² The group’s work offers replicable strategies for building spaces that support infection control and that promote healing.¹⁹³

1. Mission-Driven

In *Select Projects: Infectious Disease Mitigation*, MASS Design Group described the mission of their organization as, “From the beginning, MASS, or a Model of Architecture Serving Society, has been committed to dignifying design that creates transformative impact.”¹⁹⁴ MASS is registered as a 501(c)3 not-for-profit organization with offices in Boston, Massachusetts and Kigali, Rwanda. In a conversation with Vikram

¹⁹² Phillip Kennicott, “Designing to Survive,” *Washington Post Magazine*, July 13, 2020, <https://www.washingtonpost.com/magazine/2020/07/13/pandemic-has-shown-us-what-future-architecture-could-be/>.

¹⁹³ Kennicott.

¹⁹⁴ MASS Design Group, *Select Projects: Infectious Disease Mitigation* (Boston: MASS Design Group, March 2020), https://massdesigngroup.org/sites/default/files/multiple-file/2020-03/Infectious%20Disease%20Mitigation_Portfolio_1.pdf.

Prakash on the podcast *Architecture Talk*, co-founder Michael Murphy said that being a non-profit meant leveraging a “mix of philanthropy, grants, and revenues to use architecture as a catalyst for the public good.”¹⁹⁵

As a non-profit, MASS is also managed by a board of directors that shape the vision and work of the practice.¹⁹⁶ In *Justice is Beauty*, the board of directors are described as the “stewards of our mission to work for the benefit of communities that otherwise would not have equitable access to design.”¹⁹⁷ As Ned Cramer notes in *MASS at Scale*, MASS has brought architecture to low-income countries in the form of hospitals and healthcare facilities in Rwanda and a cholera treatment center in Haiti.¹⁹⁸ In bringing architecture to these communities, MASS has also built and designed spaces to advance public health and well-being.

The board of directors also oversees an approach to architecture called *Gesamtkunstwerk* or *Total Design*, which involves integrating different disciplines and techniques to create cohesive and sustainable spaces.¹⁹⁹ Employees at MASS are drawn from many backgrounds including architecture, landscape architecture, engineering, industrial design, graphic design, film, research, fundraising, construction, and advocacy.²⁰⁰ In addition, MASS engages public health activists, educators, and specialists in all phases of their work. Through these engagements, MASS has acquired considerable knowledge and experience to design spaces that support infection control.²⁰¹

¹⁹⁵ Vikram Prakash, “Architecture in the Time of Coronavirus with Michael Murphy of MASS Design Group,” in *Architecture Talk*, May 6, 2020, podcast, MP3 audio, 51:39, <https://www.architecturetalk.org/home/69-jyaga-sa9ls-6wtnty-6wgg5-4mgza-kdpel-zdk8w>.

¹⁹⁶ “About Page,” MASS Design Group, accessed June 4, 2020, <https://massdesigngroup.org/about>.

¹⁹⁷ MASS Design Group, *Justice Is Beauty* (New York: Monacelli Press, 2019), 41.

¹⁹⁸ Ned Cramer, “MASS at Scale,” *Architect*, May 16, 2017, https://www.architectmagazine.com/design/editorial/mass-at-scale_o.

¹⁹⁹ MASS Design Group, *Justice Is Beauty*, 38.

²⁰⁰ “Jobs,” MASS Design Group, accessed June 2, 2020, <https://massdesigngroup.org/contact/jobs>.

²⁰¹ Miriam Sitz, “Architecture That’s Built to Heal: Michael Murphy’s TED Talk,” *Architectural Record*, September 16, 2016, <https://www.architecturalrecord.com/articles/11898-architecture-thats-built-to-heal-michael-murphys-ted-talk>.

Leveraging these backgrounds and partnerships, MASS employs *Total Design* in the planning, design, and development of the built environment. As Alan Ricks notes in *Justice is Beauty*, “This approach considers the entire life of a building or space, looking both inward at the design of interiors, furniture, fixtures, and hardware, and outward at a building’s role in the larger landscape, community, city, ecosystem, and beyond.”²⁰² Thus, there is a recognition that the built environment can affect and serve a community for many decades. In this context, good building design can be a long-lasting solution to the challenges of urbanization, sustainability, and disease emergence.

Alan Ricks and Michael Murphy founded MASS Design Group with a belief that architecture is more than object-driven design.²⁰³ Architecture can promote health and well-being. For more than ten years now, MASS Design Group has been “partnering with leading organizations at the front lines of the world’s major health challenges—from responding to acute epidemics of Ebola and cholera—to addressing the chronic injustices of structural health inequities.”²⁰⁴ A core goal of MASS Design Group’s work is to design spaces that support disease regulation. In a recent opinion piece in the *Boston Globe*, Michael Murphy wrote, “If spaces can be purposefully designed, they can assist in the prevention, containment, and treatment of infectious disease.”²⁰⁵ The group’s works shows that through an attention to light, airflow, nature, and spatial design, architecture can be shaped to promote healing.

2. Research, Build, and Advocacy Cycle

MASS has a dedicated team of researchers, writers, and filmmakers that study the housing, labor, and building practices near a project site in order to better understand the communities they are trying to serve.²⁰⁶ To support these efforts, MASS began bringing

²⁰² MASS Design Group, *Justice Is Beauty*, 43.

²⁰³ Sitz, “Architecture That’s Built to Heal.”

²⁰⁴ MASS Design Group, *Select Projects: Infectious Disease Mitigation*.

²⁰⁵ Michael Murphy, “The Role of Architecture in Fighting a Pandemic,” *Boston Globe*, April 6, 2020, <https://www.bostonglobe.com/2020/04/06/opinion/role-architecture-fighting-pandemic/>.

²⁰⁶ MASS Design Group, *Justice Is Beauty*, 42.

in photographers and artists to collect local narratives near a project site to inform the design process. Through this work, MASS is able to uncover local building techniques and materials, and to meet artisans and residents to partner with. In *Justice is Beauty*, MASS credits these activities with helping to “illuminate how a collaborative and locally fabricated approach to architecture can promote health and dignity.”²⁰⁷

In connection with this thesis, I visited an exhibit on the urban renewal era that MASS had developed and curated. The exhibit, *Fringe Cities: Legacies of Renewal in the Small American City* ran for many months at the Center for Architecture in Greenwich Village. Through photographs, maps, videos, and oral history, the exhibit examined the impact that urban renewal programs had on cities like Poughkeepsie, New York and Easton, Pennsylvania. As depicted in the exhibit, urban renewal programs literally drove highways through downtown cores, leaving behind barren and segregated neighborhoods and communities.²⁰⁸ Many decades later, many of the cities highlighted in the exhibit are still struggling to come back. In upstate New York, the city of Poughkeepsie is pinning a revival on the adaptive reuse of a railroad bridge-turned-public park that spans the Hudson River.²⁰⁹ At 1.2 miles long, the Walkway over the Hudson brings more than 500,000 visitors each year to Poughkeepsie, and the city’s nearby restaurants, breweries, and music venues.²¹⁰

MASS has a philosophy about design that says, “The design of our spaces has the power to hurt us or to keep us safe.”²¹¹ Through the group’s studies of water and sanitation, the health infrastructure in Liberia—or research on COVID-19—the goal is to understand the role that architecture may play in keeping communities safe. In the exhibit *Fringe*

²⁰⁷ MASS Design Group, 83.

²⁰⁸ “Fringe Cities Design Lab,” MASS Design Group, accessed June 4, 2020, <https://massdesigngroup.org/fringe-cities>.

²⁰⁹ C. J. Hughes, “Poughkeepsie, N.Y.: A Postindustrial City Ready for Its Revival,” *New York Times*, June 12, 2019, <https://www.nytimes.com/2019/06/12/realestate/poughkeepsie-ny-a-postindustrial-city-ready-for-its-revival.html>.

²¹⁰ “Our Story,” Walkway over the Hudson, accessed August 29, 2020, <https://walkway.org/about-us/our-story/>.

²¹¹ MASS Design Group, “Role of Architecture in Fighting COVID-19.”

Cities, the power of design to hurt communities was visually on display. The message from *Fringe Cities* seemed to be that the planners and designers of that era failed this important test and thus contributed to the separation of the urban planning, architecture, and public health fields. In the post-COVID-19 era, the re-integration of these disciplines offers a path to consider how the built environment can reduce a community's risk of disease, and how urban planners can make architecture more accountable and healthier.²¹²

In recent years, MASS has emerged as a champion of design that heals. Through TED Talks, exhibits, seminars, publications, podcasts, and social media, MASS has been at the forefront of a growing movement to employ architecture and design to improve health and well-being. The advocacy efforts of MASS have influenced a larger conversation that architects, planners, developers, and building operators are having about healthy buildings and sustainability. As evidenced by the growth of healthy building certification programs like LEED and Fitwel, there is a growing market and demand for buildings that can keep people healthy and safe.

In March 2020, MASS began publishing a series of guides to help restaurant owners, healthcare spaces, and the construction industry reopen safely, focusing on strategies to reduce the transmission risk of COVID-19. In many respects, these strategies reflect decisions that MASS has made throughout their practice, designing spaces that maximize light and airflow, and that connect people to fresh air. For example, in “Spatial Strategies for Restaurants in Response to COVID-19,” MASS calls on city planners to help restaurants “reclaim their role in the public realm” by creating more space for outdoor seating and dining.²¹³ By pushing tables outside, patrons are connected with fresh air, which reduces their risk of infection. In their guide on hospital settings, MASS focused on triaging the space to separate known contamination zones from non-infected areas, and to

²¹² Prakash, “Architecture in the Time of Coronavirus.”

²¹³ MASS Design Group, “Spatial Strategies for Restaurants in Response to COVID-19” (Boston: MASS Design Group, 2020), https://massdesigngroup.org/sites/default/files/multiple-file/2020-05/Spatial%20Strategies%20for%20Restaurants%20in%20Response%20to%20COVID-19_.pdf.

employ ventilation and air filtration systems to control the transmission of respiratory droplets and infections.²¹⁴

3. Impact-Based Design Methodology

For more than ten years, MASS has designed and built spaces with health-giving intent. A good example of the organization’s work is the Cholera Treatment Center in Haiti (Figure 1). For the design, MASS incorporated new technologies to treat and manage waste on-site, and employed a number of creative strategies to optimize light and airflow throughout the space.²¹⁵



Figure 1. Cholera Treatment Center in Haiti²¹⁶

In 2010, a catastrophic earthquake struck Haiti. In the wake of the earthquake, thousands of people were left without homes and sustenance, and upwards of 200,000

²¹⁴ MASS Design Group, “Role of Architecture in Fighting COVID-19.”

²¹⁵ MASS Design Group, *Justice Is Beauty*, 227.

²¹⁶ Source: Philip Stevens, “MASS Design Group’s Haiti Cholera Treatment Center Profiled in New Documentary,” Design Boom, September 21, 2016, <https://www.designboom.com/architecture/mass-design-group-haiti-gheskio-cholera-treatment-center-documentary-design-that-heals-09-21-2016/>.

people died.²¹⁷ In *Deadly River, Cholera and Cover-up in Post-Earthquake Haiti*, Ralph R. Frerichs noted, “Nine months after the earthquake, a cholera epidemic tore through the country and infected hundreds of thousands of people, with 9,000 dying from the disease.”²¹⁸

After the outbreak, a group of experts determined that the source of the disease was a UN peacekeeping camp that had been set up near a tributary of the Artibonite River.²¹⁹ Channeling the work of John Snow, experts traced the source of the cholera bacteria back to the camp, where poor sanitation sent sewage from the camp into local waterways.²²⁰ The UN peacekeeping team staying in the camp reportedly brought the disease into Haiti from Nepal.

When cholera reached Port-au-Prince, an organization named Les Centres GHESKIO set up makeshift tents to treat people suffering from the disease. GHESKIO was founded in 1982 to fight HIV/AIDS and other infectious disease like TB and cholera.²²¹ GHESKIO brought in MASS to study the conditions inside the tents.²²² MASS found that the tents provided little light and ventilation, and provided no relief for the smell of human waste.²²³ When the waste from the tents continued to re-contaminate the water table and spread the disease, GHESKIO asked MASS to design and build a permanent wastewater treatment center.²²⁴

²¹⁷ Ralph R. Frerichs, *Deadly River: Cholera and Cover-up in Post-Earthquake Haiti* (Ithaca: Cornell University Press, 2017), 16.

²¹⁸ Frerichs, 16.

²¹⁹ Camila Domonoske, “U.N. Admits Role in Haiti Cholera Outbreak That Has Killed Thousands,” National Public Radio, August 18, 2016, <https://www.npr.org/sections/thetwo-way/2016/08/18/490468640/u-n-admits-role-in-haiti-cholera-outbreak-that-has-killed-thousands>.

²²⁰ Domonoske.

²²¹ “About GHESKIO,” Haitian Global Health Alliance,” accessed June 7, 2020, <https://www.gheskio.org/about/>.

²²² John Cary, “In Haiti, a Building Fights Cholera,” *New York Times*, September 12, 2017, <https://www.nytimes.com/2017/09/12/opinion/fighting-cholera-haiti.html>.

²²³ Cary.

²²⁴ Stevens, “MASS Design Group’s Haiti Cholera Treatment Center.”

For the design, MASS incorporated a roof and series of windows to admit light, and to divert rainwater that is stored, treated, and then used as clean water in showers and sinks.²²⁵ To decontaminate waste, MASS employed a water purification technology called anaerobic baffled reactors to treat and clean sewage. In *How a Building Fights Cholera*, John Cary explains that, “The technology functions like a septic system, using bacteria to treat sewage and contaminated water, and to turn it into clean water.”²²⁶

MASS also built-in several other systems to regulate disease. They designed a pavilion structure above the reactors to maximize airflow, and they sealed the cement floors of the facility with epoxy to control bacteria.²²⁷ In addition, the façade of the facility “features over 8,000 small windows or apertures that were designed for daylighting and ventilation.”²²⁸ Each of the windows in the façade was sculpted by hand. In “A Building Designed to Solve Haiti’s Cholera Problem,” Liz Stinson notes how MASS designed the space with the climate in mind, “The Cholera Treatment Center smartly embraces Haiti’s warm temperatures and sea breezes (for cross-ventilation and thermal energy) rather than fighting its natural environment.”²²⁹

4. Core Design Strategies and Approaches

A consistent element in the organization’s work is the incorporation of large windows and openings within a building’s envelope to maximize an occupant’s exposure to natural light. At MASS, architects design buildings with the climate around a site in mind. Understanding the local climate helps the architects determine how to orient a building to “absorb, reflect, and transmit” the sun’s rays.²³⁰ This knowledge also shapes how fresh air can be brought into a space, and how nature can be integrated into the design.

²²⁵ MASS Design Group, *Justice Is Beauty*, 227.

²²⁶ Cary, “In Haiti, a Building Fights Cholera.”

²²⁷ Stevens, “MASS Design Group’s Haiti Cholera Treatment Center.”

²²⁸ MASS Design Group, *Justice Is Beauty*, 227.

²²⁹ Liz Stinson, “A Building Designed to Solve Haiti’s Cholera Problem,” *Wired*, March 11, 2015, <https://www.wired.com/2015/03/building-designed-solve-haitis-cholera-problem/>.

²³⁰ “Passive Design: The Latest Architecture and News,” ArchDaily, accessed April 28, 2020, <https://www.archdaily.com/tag/passive-design>.

Many projects harness elements of nature—sun, wind, and breezes—to heat, cool, and illuminate interior spaces. These practices reflect the organization’s commitment to sustainable design. Taken together, the application of natural light and fresh air makes a built environment healthier and more resilient.

In *Daylight, Architecture, and Health*, Mohamed Boubekri writes, “Sunlight, affects in no small way, the psychological and physiological health of building occupants and their overall well-being.”²³¹ This sentiment had particular resonance during COVID-19. To mitigate the spread of COVID-19, many regions of the world were put on lockdown. For many weeks and months, people sheltered in their homes, going outside only for supplies or for some exercise. During this period, their home suddenly became their office, classroom, gym, coffee shop, and recreation center. Being in a sun-drenched home or apartment felt more important than ever. It is widely known that natural light can boost a person’s mood and sense of well-being, but researchers are now going much further. According to Daniel González Maglio, “There is now limited but convincing evidence that moderate sunlight exposure is capable of modulating the immune system and improving health.”²³² Maglio is a photo-immunology researcher at the University of Buenos Aires. For city dwellers, being able to access natural light and fresh air on a balcony, roof, or terrace became a luxury during the pandemic. For MASS, these attributes are not luxuries. They are essential ingredients in a building’s design.

²³¹ Mohamed Boubekri, *Daylighting, Architecture and Health: Building Design Strategies* (Amsterdam: Architectural Press, 2008).

²³² Richard Schiffman, “Let the Sunshine In,” *New York Times*, April 28, 2020, <https://www.nytimes.com/2020/04/28/well/live/coronavirus-sunlight-uv-stress-mood-immune-system-vitamin-D.html?searchResultPosition=1>.



Figure 2. The GHESKIO Tuberculosis Hospital Employs Various Infection Control Strategies²³³

MASS has built ten healthcare facilities that serve more than 40,000 patients annually.²³⁴ In many of these facilities, MASS sited hallways on the buildings' exterior "so that patients and staff can move throughout the hospital in open-air."²³⁵ Being able to access fresh air in a hospital helps reduce the rate of bacterial infections. Fresh air is also a good prescription for respiratory illnesses like TB. By bringing patients and staff outside, the design also connects them with nature. Many of MASS Design Group's healthcare facilities feature native plants and trees, along with gardens, walkways, and trails. For the design of the Butaro District Hospital in Rwanda, every bed faces a view of nature from courtyard gardens to the surrounding valleys and terraced hillside.²³⁶

²³³ Source: MASS Design Group, *Justice Is Beauty*, 199.

²³⁴ MASS Design Group, "10 Years at MASS," January 14, 2020, Vimeo, video, 3:27, <https://vimeo.com/384803038>.

²³⁵ MASS Design Group, "The Butaro District Hospital."

²³⁶ MASS Design Group, *Justice Is Beauty*, 49.

The Butaro District Hospital in Rwanda also employed various systems to mitigate the transmission of airborne pathogens throughout the campus.²³⁷ As an example, “Cross-ventilation in the hospital is supported through the use of high-volume, low-speed fans, louvers, large operable windows, and high ceilings to circulate air comfortably and reduce the risk of reinfection among the patients.”²³⁸ These same strategies can help reduce droplet spread in congregate care facilities like nursing homes. Nursing homes became hotspots for the transmission of COVID-19, affecting long-term care facilities in both urban and rural areas.²³⁹

5. Summary

MASS Design Group’s work references elements of biophilic design as well as the sanatorium movement in the nineteenth century. The design of sanatoria were a prescription for TB. Architectural elements like terraces and balconies were intended to “provide key ingredients for recovery: dry, fresh air, and sunshine.”²⁴⁰ MASS Design Group has also incorporated airflow and cross-ventilation strategies in their work to contain respiratory infections. As an example, for the design of a hospital in Liberia, a cross-ventilation system was devised that combines “natural ventilation from windows and breeze blocks with solar chimneys that heat up and pull contaminated air out of the ward spaces.”²⁴¹ Figure 3 highlights these strategies. All of these strategies have their roots in 19th and early 20th century architecture and design.

²³⁷ MASS Design Group, “The Butaro District Hospital.”

²³⁸ MASS Design Group.

²³⁹ “COVID-19 Poses Particular Challenges for Nursing Homes,” Johns Hopkins University Hub, April 1, 2020, <https://hub.jhu.edu/2020/04/01/alice-bonner-coronavirus-nursing-homes/>.

²⁴⁰ Elizabeth Yuko, “How the Tuberculosis Epidemic Influenced Modernist Architecture,” Bloomberg CityLab, October 30, 2018, <https://www.bloomberg.com/news/articles/2018-10-30/what-architecture-learned-from-tb-hospitals>.

²⁴¹ “Liberia Health Infrastructure Standards,” MASS Design Group, accessed December 28, 2019, <https://massdesigngroup.org/work/research/liberia-health-infrastructure-standards>.

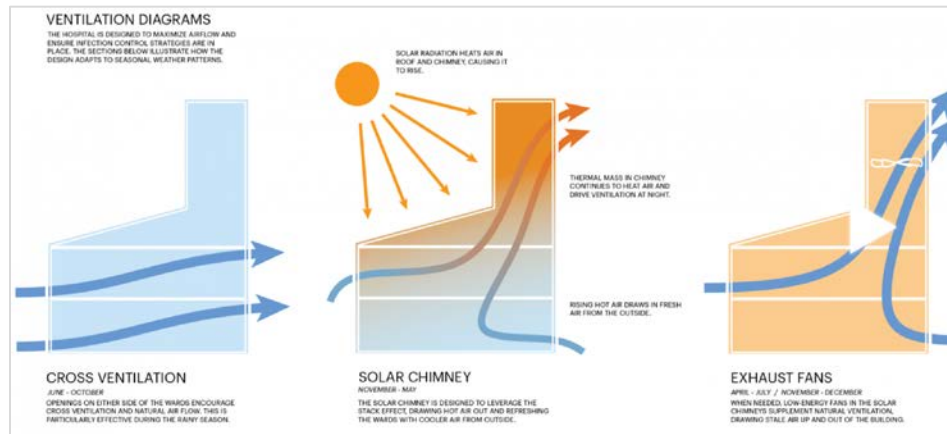


Figure 3. Cross-Ventilation Strategy for New Redemption Hospital Caldwell in Liberia²⁴²

In March 2020, MASS began publishing a series of tips and guidelines on how to design and retrofit different types of spaces for infection control.²⁴³ These tips include airflow strategies that can dilute contaminated air or droplets and spatial designs that sequence the flow of people through spaces to reduce congestion.²⁴⁴ These strategies can help planners reconfigure the layout of workplaces and design-out crowded waiting areas in hospitals and transport hubs. As Alyssa Giacobbe points out in *Architectural Digest*, “While social distancing would seem to be a necessary, if (hopefully) temporary, action, it is reasonable to think that concerns about future viruses might encourage architects to design with an eye toward open spaces that enable and encourage people to spread out.”²⁴⁵ MASS Design Group’s work and strategies can help the world community reopen after COVID-19 is contained, and can help the world community shape the built environment to protect against future pandemics.²⁴⁶

²⁴² Source: “New Redemption Hospital Caldwell,” Mass Design Group, accessed September 1, 2020, <https://massdesigngroup.org/work/design/new-redemption-hospital-caldwell>.

²⁴³ MASS Design Group, “Role of Architecture in Fighting COVID-19.”

²⁴⁴ MASS Design Group.

²⁴⁵ Giacobbe, “How the COVID-19 Pandemic Will Change the Built Environment.”

²⁴⁶ Katherine Guimang, “A Conversation with Katie Swenson on Rebuilding Trust through the Design of Safe and Healthy Spaces,” Archinect, April 8, 2020, <https://archinect.com/features/article/150188920/a-conversation-with-katie-swenson-on-rebuilding-trust-through-the-design-of-safe-and-healthy-spaces>.

B. CASE STUDY: ARCHIVE GLOBAL

ARCHIVE Global is a non-profit organization with offices in London and New York City. The group has been involved in projects around the world, including Haiti, Ethiopia, Bangladesh, Cameroon, London, and Camden, New Jersey. The group develops designs strategies to help control the spread of disease. According to the group, their work shows that “simple, cost-effective improvements and scalable interventions represent a preventable model that is replicable and sustainable.”²⁴⁷

1. Mission-Driven

In a presentation on the relationship between design, development, and disease at Ensia Live in 2013, Peter Williams said that, “The place that people call their home, and the health risks they face, are interdependent.”²⁴⁸ During his talk, he discussed how overcrowded living conditions exacerbate the transmission of respiratory infections like tuberculosis, and how poorly ventilated spaces contribute to indoor air pollutants that make people sick.²⁴⁹

In 2006, Williams founded ARCHIVE Global to “prioritize housing design as a key strategy in combatting disease around the world.” As an architect, he founded the organization with a belief in architecture’s relevance to public health.²⁵⁰ The name ARCHIVE Global stands for “Architecture for Health in Vulnerable Environments.”²⁵¹ It goes by the acronym ARCHIVE.

²⁴⁷ ARCHIVE Global, *2014 Annual Report* (New York: ARCHIVE Global, 2015), 4, <https://archive.global.org/wp-content/uploads/2020/07/Annual-Report-2014-Reduced.pdf>.

²⁴⁸ ARCHIVE Global, “Peter Williams Talks Design, Development and Disease at Ensia Live,” June 5, 2013, YouTube, video, 37:13, https://www.youtube.com/watch?v=YlrL3Up8_6E&feature=youtu.be.

²⁴⁹ ARCHIVE Global.

²⁵⁰ ARCHIVE Global, “Mashable Speaks with ARCHIVE’s Founder Peter Williams,” April 29, 2012, YouTube, video, 5:11, <https://www.youtube.com/watch?v=nqnEoygVZiI&feature=youtu.be>.

²⁵¹ ARCHIVE Global, “Our Story.”

ARCHIVE is managed by a board of directors that directs the mission of the organization to apply design strategies to “reduce the burden of disease.”²⁵² ARCHIVE’s work is supported by fundraising efforts, and through partnerships with such organizations as UBS, the National Health Service (NHS), the World Bank, and USAID. ARCHIVE’s work encompasses the worlds of international development, architecture, and public health.²⁵³ To carry out this work, members of the board are drawn from a variety of disciplines including architecture, real estate, academia, finance, fundraising, public health, international development, engineering, and construction management.

2. Research, Build, and Advocacy Cycle

The group’s practice is organized into three interconnected areas: research, advocacy, and construction.²⁵⁴ These paths often come together in a single project. A good example is a project that ARCHIVE led in Haiti in 2010. When ARCHIVE arrived in Haiti, the country was beset by an earthquake that destroyed hundreds of thousands of homes, and an outbreak of TB. With funding from UBS and USAID, ARCHIVE oversaw the design and construction of TB-resistant homes for a community in Saint-Marc.

According to the World Health Organization (WHO), at the time of the earthquake, Haiti had “the highest tuberculosis incidence in the Americas (230 per 100,000 population in 2010).”²⁵⁵ In Saint-Marc, people were living in substandard housing conditions that were overcrowded. The air quality in many homes was poor with high levels of moisture and humidity. The group’s research team knew that these conditions can create a perfect storm for the bacteria that causes TB.²⁵⁶ According to the group, an effective housing

²⁵² ARCHIVE Global, *2017 Annual Report* (New York: ARCHIVE Global, 2018), 5, <https://indd.adobe.com/view/ab34e59c-1c85-4af6-b3d4-e00ea863b752>.

²⁵³ “About,” Center for Active Design, accessed May 26, 2020, <https://centerforactivedesign.org/about/>.

²⁵⁴ ARCHIVE Global, “Our Story.”

²⁵⁵ Serena P. Koenig et al., “Tuberculosis in the Aftermath of the 2010 Earthquake in Haiti,” *Bulletin of the World Health Organization* 93 (2015), <http://dx.doi.org/10.2471/BLT.14.145649>.

²⁵⁶ Uculia Wang, “ARCHIVE Global: Fighting Disease with Low-Tech, Low-Cost Home Design,” *Guardian*, April 14, 2014, <https://www.theguardian.com/sustainable-business/archive-global-low-tech-cost-design-disease>.

strategy to lower relative humidity—and improve indoor air quality (IAQ)—involves proper ventilation and airflow, along with the right building materials.²⁵⁷

ARCHIVE then held a competition to design a healthy building prototype for the community of Saint-Marc. According to Peter Williams, the project was aimed at helping the community rebuild after the earthquake, and for the model to be replicated in other areas.²⁵⁸ Williams also saw the project as an avenue for “demonstrating that among the poorest, housing can be a central strategy in improving health.”²⁵⁹

ARCHIVE’s design brief called for innovative strategies to curb the spread of TB, and for design specifications that can be built with local building materials and techniques.²⁶⁰ Each entrant was asked to keep the cost of the design below \$50,000.²⁶¹ The contest received a total of 147 entries. ARCHIVE selected the winning design called “Breathe House,” in which natural light and cross-ventilation are incorporated into the space, along with high ceilings, fans, and windows to promote airflow.²⁶² The design also uses bamboo and perforated wood panels for walls.²⁶³ These materials were selected in order to bring in fresh air, and to let the space breathe. A project team from the University of Virginia School of Architecture developed the design. Figure 4 is an image of “Breathe House.”

²⁵⁷ Wang.

²⁵⁸ Branden Klayko, “One Year In: Five Healthful Homes for Haiti,” *Architect’s Newspaper*, January 12, 2011, <https://www.archpaper.com/2011/01/one-year-in-five-healthful-homes-for-haiti/>.

²⁵⁹ Klayko.

²⁶⁰ Klayko.

²⁶¹ C. J. Hughes, “In Haiti, ARCHIVE Houses Aim to Curb Disease through Design,” *Architectural Record*, January 12, 2011, <https://www.architecturalrecord.com/articles/2100-in-haiti-archive-houses-aim-to-curb-disease-through-design?v=preview>.

²⁶² Irina Vinnitskaya, “Peter Williams for Architecture for Health in Vulnerable Environments (ARCHIVE),” *ArchDaily*, April 26, 2013, <http://www.archdaily.com/364901/peter-williams-for-architecture-for-health-in-vulnerable-environments-archive/>.

²⁶³ Hughes, “In Haiti, ARCHIVE Houses Aim to Curb Disease.”

ARCHIVE built five “Breathe House” multi-family units in Saint-Marc. According to the group, the units provide housing for 80 residents.²⁶⁴ The group employed local builders in the construction, and used local building materials and practices. In 2014, ARCHIVE turned the project and design specifications over to a local partner to build additional units. “Breathe House” shows that healing design strategies can be low-cost and replicable.



Figure 4. Breathe House in Saint-Marc, Haiti²⁶⁵

3. Impact-Based Design Methodology

In Dhaka, Bangladesh, and in other developing parts of the world, the homes are built with mud and dirt flooring. Studies show that the dirt flooring can become a “transmission gateway” for the pathogens that cause such water-borne diseases as typhoid fever, Hepatitis A, and bacterial diarrhea.²⁶⁶ According to the WHO, diarrhea is a major

²⁶⁴ “Health and Housing in Haiti,” ARCHIVE Global, accessed September 1, 2020, <https://archive.global.org/our-work/health-and-housing-in-haiti/>.

²⁶⁵ Source: Eliza Barclay, “Home Sick Home? Architect Goes After Tuberculosis in Haiti,” National Public Radio, June 28, 2011, <https://www.npr.org/sections/health-shots/2011/06/27/137455615/home-sick-home-architect-goes-after-tuberculosis-in-haiti>.

²⁶⁶ ARCHIVE Global, “Mud to Mortar.”

cause of death in Bangladesh each year.²⁶⁷ In 2014, ARCHIVE launched an initiative called Health From the Ground Up that focuses on replacing the dirt floors with sand, brick, and concrete.²⁶⁸

For the design, ARCHIVE selected concrete because it is easy to clean and maintain, and according to the group, “provides an impenetrable barrier to disease.”²⁶⁹ The group also developed a simple process to fill the dirt floors with layers of sand and brick, and to top them with concrete.²⁷⁰ ARCHIVE’s approach is to design housing solutions that are accessible and low-cost. In Dhaka, the group created a simple flooring intervention plan that can be constructed by local masons in a matter of days.

With funding from donations and partners, ARCHIVE renovated ten homes in Dhaka, replacing the dirt floors with a concrete foundation. According to the group, the renovations “reduced the prevalence of diarrheal disease by 75 percent in children under five years old in beneficiary households.”²⁷¹ Since the initial pilot, ARCHIVE has partnered with Grimshaw Architects to renovate additional homes in Dhaka, and in Savar, Bangladesh. The group has also trained local masons in these areas to use the flooring technique in other homes.²⁷²

In Cameroon, the group developed a housing strategy to help combat the spread of malaria. The design creates defensible space by using screened doors to prevent mosquitoes from coming inside.²⁷³ The design also incorporates eaves and windows into the design to

²⁶⁷ Ahmed Ehsanur Rahman et al., “Childhood Diarrhoeal Deaths in Seven Low- and Middle-Income Countries,” *Bulletin of the World Health Organization* 92 (2013), <http://dx.doi.org/10.2471/BLT.13.134809>.

²⁶⁸ McMenamin, “Poured Concrete Flooring Eliminates Disease.”

²⁶⁹ ARCHIVE Global, “Mud to Mortar.”

²⁷⁰ ARCHIVE Global.

²⁷¹ Olivia Benjamin, “Mud to Mortar: Preventing Disease through Interventions in the Built Living Environment,” DefeatDD, May 14, 2018, <https://www.defeatdd.org/blog/mud-mortar-preventing-disease-through-interventions-built-living-environment>.

²⁷² Benjamin.

²⁷³ “Building Malaria Prevention,” ARCHIVE Global, accessed July 22, 2020, <http://archiveglobal.org/cameroon/>.

reduce moisture and humidity, and to promote airflow.²⁷⁴ According to the group, since 2014, more than 400 homes have been renovated using the “malaria-proof” intervention strategy.²⁷⁵ Furthermore, the group has trained more than 3,000 community members on how to apply these strategies in their homes.²⁷⁶

In London, the group ran an outreach campaign to raise awareness about the relationship between the built environment and TB.²⁷⁷ The group visited schools in several neighborhoods and talked to students about identifying “TB triggers” in their homes like overcrowding and poor ventilation.²⁷⁸ In Camden, New Jersey, the group ran an asthma-awareness campaign. The group met with families and conducted environmental assessments of their homes to identify such asthma triggers as dust and mold.²⁷⁹ In both campaigns, the group prioritized the role that simple housing strategies—for example, bringing in fresh air and filtering it—can play in controlling these diseases.

4. Core Design Strategies and Approaches

The group’s approach to design is bottom-up and human-centered. At the beginning of a project, the group spends a great deal of time learning about the people and community they are trying to serve. For example, they learn about local housing conditions, along with building practices and materials. According to Peter Williams, this time is “spent learning, listening, and understanding how people build, at what cost, over what period of time.”²⁸⁰ This information helps the group design housing interventions that are within market, and that may be easily replicated by local builders.²⁸¹

²⁷⁴ ARCHIVE Global.

²⁷⁵ ARCHIVE Global, *2014 Annual Report*.

²⁷⁶ ARCHIVE Global.

²⁷⁷ “Happy Healthy Households,” ARCHIVE Global, accessed July 22, 2020, <http://archiveglobal.org/happy-healthy-households/>.

²⁷⁸ ARCHIVE Global.

²⁷⁹ ARCHIVE Global, *2014 Annual Report*.

²⁸⁰ David Doody, “Peter Williams: Building a Healthy Home,” *Ensia*, February 11, 2013, <https://ensia.com/interviews/peter-williams-building-a-healthy-home/>.

²⁸¹ Doody.

The group also learns from homeowners and residents. Williams says that in the communities they have worked in, there is a long tradition of people finding ways to “refashion and continually improve their homes.”²⁸² For ARCHIVE, this lesson is important. The group’s designs are intended to be flexible, empowering residents to modify them over time to suit their needs.

Many of the group’s housing designs focus on improving ventilation and airflow in a space to improve IAQ, and to reduce the incidence of airborne pathogens and pollutants.²⁸³ According to Williams, one of the group’s strategies involves “inserting plastic water bottles, which are cut open at both ends, into the wall, to promote airflow.”²⁸⁴ The group’s designs also incorporate windows, high ceilings, and openings in a building’s envelope to maximize sunlight and cross-ventilation.

5. Summary

ARCHIVE develops low-tech and low-cost solutions to mitigate health risks in the built environment. The group engages local residents and artisans in all phases of a project. By building co-creators, the group aims to develop housing strategies that may be easily replicated, and that can use local materials, labor, and practices.

The group has been involved in projects to control the spread of airborne pathogens like TB, along with water and vector-borne diseases. For the group, a core prevention strategy has involved improving the IAQ in a space. ARCHIVE’s design strategies focus on proper ventilation and airflow to reduce the presence of indoor pollutants that make people sick. The incorporation of windows and high ceilings in a space, along with the right building materials, can replace stale air with fresh air.

²⁸² Doody.

²⁸³ ARCHIVE Global, “Architecture for Health,” September 23, 2015, Vimeo, video, 3:36, <https://vimeo.com/140226335>.

²⁸⁴ Wang, “ARCHIVE Global.”

C. CONCLUSION

MASS Design Group and ARCHIVE Global treat the built environment as a prescription for disease. Both groups prioritize the role that such health-giving attributes as light, airflow, nature, spatial design, and the right building materials play in promoting healing, and controlling the spread of disease. Their work shows that healing design strategies can be implemented in both the developing world, and here at home.

MASS and ARCHIVE develop design strategies that reflect the needs of the communities they are trying to serve. Both organizations cultivate co-creators, partnering with local residents, masons, and artists to develop housing solutions that may be replicated with local building materials and practices. Both organizations also integrate the built environment into the local climate. Through building orientation and siting, their work aims to maximize such natural forces as wind, breezes, and light to heat, cool, and illuminate interior spaces.²⁸⁵

MASS and ARCHIVE create environments that aim to improve the health and well-being of building occupants, and to reduce their exposure to such respiratory infections as TB. Since March 2020, both organizations have played an important role in helping policymakers develop strategies to reduce the transmission risk of COVID-19. To a great extent, these strategies evoke each group's own work, designing spaces that maximize airflow to dilute airborne pathogens that can make people sick.

Many of their designs feature openings in a building's envelope to connect occupants with fresh air, natural light, and views of nature. The incorporation of high ceilings, fans, and eaves into a design also promotes healthy IAQ. These strategies are largely low-tech and can be replicated in a variety of settings. Their work shows that an architecture can be created that improves health through building designs that can be scaled and adapted, depending on the needs of the community.

²⁸⁵ Manoush Zomorodi, "The Power of Spaces," July 24, 2020, in *Ted Radio Hour*, produced by National Public Radio, podcast, MP3 audio, 43:53, <https://www.npr.org/programs/ted-radio-hour/894682150/the-power-of-spaces>.

IV. APPLYING HEALING DESIGN PRINCIPLES

This chapter will review the work of a group of researchers, scientists, and architects that are building prototypes of healthy buildings and environments. Through science and observations, this body of work is aimed at testing and validating the role that good building design plays in health and well-being. This chapter will also review current trends in hospital design, in which biophilic elements are being maximized to improve quality of care and patient outcomes. This chapter then examines how cities can manage density better by diversifying the typology of buildings.

There is an opportunity now to rethink how buildings are designed. Rather than treating buildings as “machines,” many architects, as Kennicott notes, are beginning to embrace the idea that buildings are “living organisms.”²⁸⁶ The built environment can breathe and learn; and buildings can be in-tune with their surroundings. Buildings can be flexible and adaptable, and responsive to biological patterns and rhythms.²⁸⁷ This chapter reviews these attributes and explores how they may be applied to promote health and resilience.

A. DESIGN THE PROCESS OF BUILDING AS WELL AS THE BUILT ENVIRONMENT

This section examines the work of researchers, scientists, and architects who are using new technologies to design and operate healthy buildings and environments. Their work provides a toolkit to design buildings that are healthy and resilient to disease. This section also explores how spaces may be designed to expand and contract, based on need, and how buildings can support infection control.

1. Buildings That Are Smart

In 2016, Harvard University began a project to retrofit a wood-framed building on the school’s campus. For the renovation, Harvard brought in the architecture and

²⁸⁶ Kennicott, “Designing to Survive.”

²⁸⁷ Kennicott.

engineering firms Snøhetta and Skanska to redesign the space. The site housed the school's Center for Green Buildings and Cities (CGBC) program. Ali Malkawi, the director of the Center, encouraged the design team to "take the place apart," and rebuild it to control its own temperature, airflow, and light.²⁸⁸ Malkawi is also a professor of Architectural Technology at Harvard, and according to the Graduate School of Design, is an "expert in building simulation, energy conservation, and sustainability in buildings."²⁸⁹ Malkawi's vision for the redesign was for the building to produce more energy than it consumes.²⁹⁰ He also saw the project as an opportunity to reimagine how buildings function and operate. The space that Malkawi and the design team built is now called House Zero.

The project entailed ripping out the HVAC system, and reengineering the space to harness natural forces to heat, cool, and ventilate it.²⁹¹ According to the CGBC, over a period of 24 months, the design team transformed the space into a "living laboratory" to help students, researchers, and faculty members "understand buildings in new ways."²⁹² Rather than tightening-up the building, and shielding it from outdoor air, the building envelope was opened-up to allow the building to "connect with and respond to its natural environment to promote efficiency and health."²⁹³

Buildings that are completely sealed rely entirely upon mechanical systems to heat and cool the indoor environment. These systems consume considerable energy, and they do a poor job of regulating IAQ.²⁹⁴ Instead of replacing stale air in a space, mechanical

²⁸⁸ Davidson, "The Greenest Building in America?"

²⁸⁹ "Ali Malkawi," Harvard Graduate School of Design, accessed June 23, 2020, <https://www.gsd.harvard.edu/person/ali-malkawi/>.

²⁹⁰ Alisha Ukani, "Harvard's 'HouseZero,'" *Harvard Magazine*, August 3, 2017, <https://www.harvardmagazine.com/2017/08/harvard-s-housezero-emissions-green-building>.

²⁹¹ Justin Davidson, "That Office AC System Is Great—at Recirculating Viruses," *Intelligencer*, May 22, 2020, <https://nymag.com/intelligencer/2020/05/that-office-ac-system-is-great-at-recirculating-viruses.html>.

²⁹² "Harvard HouseZero," Snøhetta, accessed September 1, 2020, <https://snohetta.com/projects/413-harvard-housezero>.

²⁹³ "CGBC Headquarters: HouseZero," Harvard Center for Green Buildings and Cities, accessed June 16, 2020, <https://harvardcgbc.org/research/housezero/>.

²⁹⁴ "HVAC Energy Breakdown," Australian Department of Agriculture, Water and the Environment, September 2013, <https://www.environment.gov.au/system/files/energy/files/hvac-factsheet-energy-breakdown.pdf>.

systems largely recirculate it. By comparison, passive ventilation systems harness the forces of wind and buoyancy to bring fresh air inside, and to maintain thermal comfort.²⁹⁵ A passive building design works by bringing in fresh air through openings—vents, ducts, louvers, and operable windows—in a building’s envelope.

Malkawi’s design recalls how buildings were designed in the past, before the advent of mechanical systems. According to Michael Murphy from MASS, back then, “Buildings were designed with a ratio of windows to floor plate that depended on climate.”²⁹⁶ In colder climates and regions, buildings were oriented to collect solar energy through south-facing windows, and to employ natural cross-ventilation strategies to adjust heating and cooling needs within a space.²⁹⁷ In cities like Cambridge, Massachusetts, houses were also built with thick walls and materials.²⁹⁸ According to Jonathan Shaw, for the design of House Zero, “many tons of concrete mass were added in the floors between the stories during the renovation, to stabilize daily temperatures from night to day, and seasonally across frigid winters and scorching summers.”²⁹⁹

The “brain” of House Zero consists of sensors and cables that collect millions of data points each day to control the indoor environment without an HVAC system.³⁰⁰ According to the CGBC, the data is used to run a series of algorithms that “will prompt the building to adjust, reconfigure, and harmonize its daily operation based on future weather forecasts.”³⁰¹ The system literally opens and closes the building’s windows and shades based on “inputs about temperature, rain, wind direction, and indoor CO₂ levels and airflows.”³⁰²

²⁹⁵ Walker, “Natural Ventilation.”

²⁹⁶ Davidson, “That Office AC System Is Great—at Recirculating Viruses.”

²⁹⁷ Harvard Center for Green Buildings and Cities, “CGBC Headquarters.”

²⁹⁸ Davidson, “That Office AC System Is Great—at Recirculating Viruses.”

²⁹⁹ Jonathan Shaw, “The Brain in the Basement,” *Harvard Magazine*, June 11, 2018, <https://www.harvardmagazine.com/2018/07/harvard-house-zero>.

³⁰⁰ Shaw.

³⁰¹ Harvard Center for Green Buildings and Cities, “CGBC Headquarters.”

³⁰² Shaw, “The Brain in the Basement.”

Studies show that the data inputs that House Zero collects, monitors, and adjusts affect health and well-being. For example, when the air in a space is saturated with pollutants from carbon dioxide and/or volatile organic compounds (VOCs), it can make building occupants sick.³⁰³ VOCs are emitted by common products and materials, including paints, solvents, cleansers, air fresheners, furnishings, and office equipment.³⁰⁴ According to the EPA, the presence of VOCs in a space has been linked to such health effects as ear, nose, and throat irritation; liver and kidney damage; and cancer.³⁰⁵ Being able to control VOCs and regulate indoor air quality (IAQ) can make the built environment healthier. High IAQ is also associated with lower rates of absenteeism and increased productivity in the workplace.³⁰⁶ According to the Lawrence Berkeley National Laboratory, improving IAQ in offices alone could add \$20 billion back into the U.S. economy each year.³⁰⁷

High indoor CO₂ levels are also a warning sign that ventilation rates are low, and that not enough fresh air is coming inside. Studies show that poorly ventilated spaces increase the risk that respiratory pathogens like COVID-19 may be transmitted through the air.³⁰⁸ When people talk, breathe, cough, shout, or sing, they exhale CO₂.³⁰⁹ If a building can monitor the level of CO₂ exhalations, it can help reduce the risk that these sources become infectious aerosols.³¹⁰

A recent study by the National Institute for Occupational Safety and Health (NIOSH) found that indoor humidity levels play an important role in the “infectivity” of

³⁰³ Anthes, *The Great Indoors*, loc. 1224.

³⁰⁴ “Volatile Organic Compounds’ Impact on Indoor Air Quality,” Environmental Protection Agency, accessed August 29, 2020, <https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality>.

³⁰⁵ Environmental Protection Agency.

³⁰⁶ W. J. Fisk, D. Black, and G. Brunner, “Benefits and Costs of Improved IEQ in U.S. Offices,” *Indoor Air* 21, no. 5 (2011): 357–67, <https://doi.org/10.1111/j.1600-0668.2011.00719.x>.

³⁰⁷ Fisk, Black, and Brunner.

³⁰⁸ Qian and Zheng, “Ventilation Control for Airborne Transmission.”

³⁰⁹ Davidson, “That Office AC System Is Great—at Recirculating Viruses.”

³¹⁰ Julian W. Tang et al., “Airflow Dynamics of Human Jets: Sneezing and Breathing—Potential Sources of Infectious Aerosols,” *PLoS ONE* 8, no. 4 (2013), <https://doi.org/10.1371/journal.pone.0059970>.

aerosolized droplets.³¹¹ According to the study, when the air in a space is too dry (below 40 percent relative humidity), droplets from a sneeze or cough can circulate in the air longer, and travel farther, making it easier to breathe in.³¹² By comparison, when the relative humidity in a space is slightly moist (between 40 percent to 60 percent relative humidity), airborne droplets become damaged and inactive, and fall to the ground.³¹³

Ultimately, Malkawi's vision for House Zero is for it to "serve as a transferrable model" for residential homes and commercial spaces.³¹⁴ In *Is This Harvard Prototype the Greenest Building in America*, Justin Davidson notes that House Zero may portend a "future in which every tract house, tenement, and landmark could receive a range of possible upgrades, from a radical overhaul to a natural ventilation kit comprised of cables, sensors, and window actuators."³¹⁵

In Rochester, Minnesota, a team of scientists, architects, and engineers are studying how to design workspaces that promote health and well-being.³¹⁶ Like in House Zero, the project prioritizes the role of health-giving attributes in the design and operation of the built environment. The project is a collaboration between the Mayo Clinic and Delos. Paul and Pete Scialla from the WELL Building Standard founded and run Delos.

For this project, a 5,500 square-foot office space was created to study the relationship between human health and the built environment.³¹⁷ The space is called the Well Living Lab. The lab's design simulates a typical open-floor office layout. A group of employees work in the lab each day. Each employee wears a biometric wristband that

³¹¹ "High Humidity Leads to Loss of Infectious Influenza Virus from Simulated Coughs," Centers for Disease Control and Prevention, March 28, 2018, <https://www.cdc.gov/index.htm>.

³¹² Great Innovations, "Home Humidity Levels Are Critical to Keeping Viruses in Check," Cision PR Newswire, April 2, 2020, <https://www.prnewswire.com/news-releases/home-humidity-levels-are-critical-to-keeping-viruses-in-check-301033883.html>.

³¹³ Great Innovations.

³¹⁴ Colin Durrant, "A House That Produces Energy," *Harvard Gazette*, June 13, 2017, <https://news.harvard.edu/gazette/story/2017/06/this-efficient-house-aims-to-end-up-producing-energy/>.

³¹⁵ Davidson, "The Greenest Building in America?"

³¹⁶ "Home Page," Well Living Lab, accessed June 28, 2020, <https://www.welllivinglab.com>.

³¹⁷ Well Living Lab.

monitors their heart rate variability and stress levels.³¹⁸ Behind the scenes, a team of scientists tweak the quality of the indoor environment and measure how these changes impact employee productivity, behavior, and well-being. For example, the scientists can change the amount of light and airflow in the lab, and record how these changes impact employee performance.

The lab is embedded with hundreds of sensors that measure the environment's temperature, humidity, sound acoustics, illumination, and air quality, including VOCs, carbon dioxide, and particulate matter.³¹⁹ The data from the sensors is routed in real-time to a control room. Inside the control room, a group of scientists monitor this data, and observe how individual variables like lighting and sound impact an employee's cognition and mood.³²⁰

The work that the Well Living Lab is performing aims to validate the role that design can play in improving the health and well-being of building occupants.³²¹ A core goal of the Well Living Lab is to contribute to the field of evidence-based research on building design and health. Ultimately, the Well Living Lab's legacy may be in supporting healthy building standards, guidelines, and processes. In so doing, the Well Living Lab may be an agent to promote the growth of certification programs like WELL and Fitwel, and the broader healthy building movement.

2. Buildings and Spaces That Support Infection Control

Smart homes and offices foretell of a future where emerging technologies are utilized to make indoor spaces healthier. But, as businesses, restaurants, schools, and retail establishments begin to open up, the urgent question now is what role can architecture play in reducing the risk of infection to the virus? In an essay for the *New Yorker*, Kyle Chayka writes how innovative periods of architecture "can be understood as a consequence of the

³¹⁸ Anthes, *The Great Indoors*, loc. 1215.

³¹⁹ Well Living Lab, "Home Page."

³²⁰ Anthes, *The Great Indoors*, loc. 1231.

³²¹ Well Living Lab, "Home Page."

fear of disease.”³²² From the design of sanatoria to treat tuberculosis to the treatment of surfaces and materials, architecture has been seen as part of the cure. In surveying the current period, Chayka writes, “In recent months, we have arrived at a new juncture of disease and architecture, where fear of contamination again controls what kinds of spaces we want to be in.”³²³

Today, the type of space that is needed to reduce the risk of contamination is largely defensive.³²⁴ To borrow an analogy from soccer, the strategy now involves putting ten players behind the ball and protecting the goal. Many offices and retail establishments have already begun reconfiguring their spaces, erecting barriers, walls, and plexiglass, and using visual cues like tape and markings to maintain safe distancing. Restaurants, schools, and hospitals have begun adopting strategies to triage and sequence the flow of people through a space, separating high-risk zones from low-risk zones. Spatial strategies like one-way traffic flows in hallways or shopping lanes are being employed to reduce density and congestion. Combined, these strategies can help people read and understand space to navigate them more safely. These strategies are likely to remain in effect until there is a vaccine for COVID-19. Even after, these strategies provide a ready-made set of prescriptions to help mitigate future disease flare-ups or outbreaks.

In late May 2020, the American Institute of Architects (AIA) released a document to provide “architects, private clients, and civic leaders a framework of strategies for reoccupying buildings and businesses.”³²⁵ AIA’s assessment tool applied the CDC framework of “hierarchy of controls” to develop an index of mitigation measures.³²⁶ The CDC model is represented as an inverted pyramid with information displayed in descending order of effectiveness. Please see Figure 5.

³²² Kyle Chayka, “How the Coronavirus Will Reshape Architecture,” *New Yorker*, June 17, 2020, <https://www.newyorker.com/culture/dept-of-design/how-the-coronavirus-will-reshape-architecture>.

³²³ Chayka.

³²⁴ Chayka.

³²⁵ American Institute of Architects, *Re-Occupancy Assessment Tool*, version 2.0 (New York: American Institute of Architects, 2020), http://content.aia.org/sites/default/files/2020-06/STN20_%20344901_ReOccupancyAssessmentTool-V02_sm_v09.pdf.

³²⁶ American Institute of Architects.

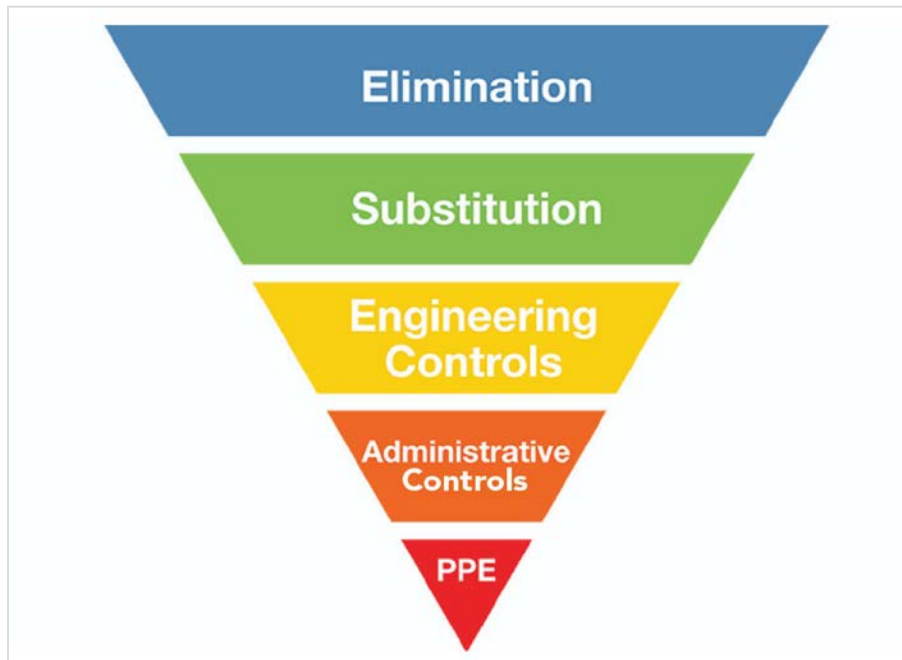


Figure 5. Hierarchy of Controls³²⁷

According to the CDC, “The most effective ways to control hazards are to systemically remove them rather than relying on the public to reduce their own exposure.”³²⁸ For COVID-19, this meant having employees and students access work and school from home, if they could, rather than crowding into offices and schools.

In the pyramid, administrative controls involve staggering employee shifts and limiting building occupancy to reduce density. It may also include on-site temperature screening of employees in offices. At the bottom of the pyramid is the selection and donning of personal protective equipment (PPE) in public spaces, including protective face coverings, gloves, and goggles.

The weight of the AIA assessment tool focuses on architecture and engineering methods to reduce exposure to the virus. Here, AIA outlines considerations in the areas of space planning, signage, plumbing, finishes and furnishings, and lighting. Much of the

³²⁷ Source: “Hierarchy of Controls,” National Institute for Occupational Safety and Health, January 13, 2015, <https://www.cdc.gov/niosh/topics/hierarchy/default.html>.

³²⁸ American Institute of Architects, *Re-Occupancy Assessment Tool*.

space in this section is devoted to mechanical and passive ventilation. These strategies include: opening operable windows to bring in outside air, increasing ventilation rates and air exchanges, installing air filters with at least MERV-13 rating, and using UV germicidal irradiation (UVGI) in mechanical ventilation paths.³²⁹ The assessment tool also calls on building owners and operators to “monitor relative humidity, temperature, and CO₂ levels regularly to identify and resolve issues quickly.”³³⁰ Where House Zero and the Well Living Lab monitor these variables with sensors, building operators may also monitor them with portable meters.

3. Adaptive Reuse: Buildings That Can Learn

When cases of the coronavirus threatened to overwhelm New York City’s healthcare infrastructure, a group of officials in government, and from healthcare, developed a creative solution to manage the surge in patients.³³¹ Working together, they began surveying existing buildings throughout the region that could be repurposed for medical screening, triage, and patient care. Sports venues, convention centers, hotels, and dorms were all considered for adaptive reuse as alternative care sites (ACS).

Adaptive reuse essentially involves changes in how buildings are used.³³² As an example, the High Line in Manhattan is an adaptive reuse project. For this project, an abandoned rail line was converted into an elevated public park. In this case, city administrators needed to urgently find space for hospital beds and units. In a matter of days, the Jacob Javits Center was transformed into a 2,900-bed field hospital.³³³ Not long after,

³²⁹ American Institute of Architects.

³³⁰ American Institute of Architects.

³³¹ Caleb Melby, Jackie Gu, and Mira Rojanasakul, “Mapping New York City Hospital Beds as Coronavirus Cases Surge,” Bloomberg, March 25, 2020, <https://www.bloomberg.com/graphics/2020-new-york-coronavirus-outbreak-how-many-hospital-beds/>.

³³² Yin, *Urban Planning for Dummies*, loc. 5209 of 8109.

³³³ Matt Hickman, “New York’s Javits Center Completes Transformation into 1,200 Bed Emergency Hospital,” *Architect’s Newspaper*, March 30, 2020, <https://www.archpaper.com/2020/03/new-york-javits-center-coronavirus-emergency-hospital/>.

the cities of Chicago and New Orleans converted their own convention centers into temporary hospitals, as did London and Seattle.³³⁴

In *How Buildings Learn*, Stewart Brand makes a case for building design that prioritizes flexibility over aesthetic and purpose.³³⁵ For Brand, buildings need to be able to evolve and “flow” over time to respond to changes around them.³³⁶ Brand’s preference for buildings that may accommodate unexpected uses offers lessons in how to design spaces for the future.³³⁷ Spaces that are adaptable can serve the short or long-term needs that may arise within a community. In the post-COVID-19 era, there is an opportunity to incentivize building design that can be scaled or modified to support another purpose.

Hospitals and healthcare facilities represent a class of infrastructure that can benefit from an adaptive approach to design. COVID-19 revealed that hospitals lacked the flexibility to easily pivot and scale-up to manage a pandemic surge.³³⁸ Going forward, hospital administrators will need to consider how their spaces can expand and contract, depending on the number of patients who come in.³³⁹ In addition to emergency beds, many hospitals will need to be able to adapt spaces for isolation units to handle infectious patients, and for anterooms for healthcare workers to safely don and doff their PPE.³⁴⁰ As James Albert notes, in a pandemic, “hospitals will need groups of rooms and entire units

³³⁴ “How Cities Mobilized to Convert Spaces into COVID-19 Care Facilities,” Jones Lang LaSalle, June 2, 2020, <https://www.us.jll.com/en/trends-and-insights/cities/how-cities-mobilized-to-convert-spaces-into-covid19-care-facilities>.

³³⁵ Stewart Brand, “Flow,” in *How Buildings Learn*, June 10, 2012, YouTube, video, 29:35, <https://www.youtube.com/watch?v=AvEqfg2sIH0&feature=youtu.be>.

³³⁶ Brand.

³³⁷ Newton D’souza, “Time, Space, and Adaptive Reuse in the Age of Social Distancing,” Archinect, May 20, 2020, <https://archinect.com/features/article/150197748/op-ed-time-space-and-adaptive-reuse-in-the-age-of-social-distancing>.

³³⁸ MASS Design Group, “Redesigning Hospital Spaces on the Fly to Protect Healthcare Workers” (fact sheet, MASS Design Group, April 28, 2020), 9, https://massdesigngroup.org/sites/default/files/multiple-file/2020-04/Redesigning%20Hospital%20Spaces%20on%20the%20Fly%20to%20Protect%20Healthcare%20Workers_4.pdf.

³³⁹ Jeremy Hsu, “How COVID-19 Could Inform the Future of Hospital Design,” *Smithsonian*, April 17, 2020, <https://www.smithsonianmag.com/innovation/how-covid-19-could-inform-future-hospital-design-180974697/>.

³⁴⁰ Hsu.

and wings that can be negatively pressurized and cut off from the rest of the hospital.”³⁴¹ Albert is an architect and principal at the firm Hord Coplan Macht. In planning for the future, hospitals may need to consider how their existing spaces can be retrofitted to quickly accommodate a surge of infected patients.

4. Better Hospital Design: Buildings That Can Heal

By the middle of the 19th century, the pavilion-style had emerged as the standard form of hospital design in the United States, and abroad.³⁴² A typical pavilion-style hospital was a low-rise (three to four stories tall) structure with U-shaped wards that extended out from a central corridor.³⁴³ The design carved-out generous space between the wards for gardens, trees, and courtyards, connecting patients with nature. The height of the hospital was kept low in order to maximize wind flow and ventilation, and the wards were oriented to maximize daylighting.³⁴⁴ Inside the wards, rows of beds were surrounded by windows to optimize light, views of nature, and cross-ventilation. Each design decision was intended to treat the hospital’s architecture as part of the cure.

By the early 20th century, hospital design began to change. As new technologies and medical specializations emerged, the hospital building began to be regarded less as a “medical instrument,” and as more of a “facilitator for current medical behaviors and practices.”³⁴⁵ The advent of elevators and HVAC systems also contributed to the change in the building’s form, and how they are operated. For critics, this shift ushered in an abiding emphasis on efficiency, costs, and standardization, which came at the expense of patient healing.³⁴⁶

³⁴¹ James Albert, “Reimagining Healthcare Design After COVID-19,” *Healthcare Design*, May 7, 2020, <https://www.healthcaredesignmagazine.com/trends/perspectives/reimagining-healthcare-design-after-covid-19/>.

³⁴² Jeanne Kisacky, *Rise of the Modern Hospital: An Architectural History of Health and Healing, 1870-1940* (Pittsburgh: University of Pittsburgh Press, 2017), loc. 701 of 8534, Kindle.

³⁴³ Anthes, *The Great Indoors*, loc. 522.

³⁴⁴ “The Innovative Design of Civil War Pavilion Hospitals,” National Museum of Civil War Medicine, February 20, 2018, <https://www.civilwarmed.org/pavilion-hospitals/>.

³⁴⁵ Kisacky, *Rise of the Modern Hospital*, loc. 462.

³⁴⁶ Anthes, *The Great Indoors*, loc. 529.

In recent years, a growing body of research is confirming what the architects of the pavilion-style of hospitals knew from theory and intuition: that the built environment plays an important role in promoting health and well-being.³⁴⁷ The research is being conducted in a number of fields from biology to psychology and building science. Much of the research now falls under the banner of evidence-based design. In healthcare settings, this research shows that “the built environment impacts patient stress, patient and staff safety, staff effectiveness, and quality of care.”³⁴⁸

In a recent essay, Justin B. Hollander and Ann Sussman call on the field of architecture to “reshape the built environment so it’s a better fit with our biological nature.”³⁴⁹ Through an attention to the rhythms and patterns of light and the natural environment, architecture can be an agent to promote healing. The architects of the pavilion-style of hospitals followed this approach. In recent years, MASS and ARCHIVE have been designing spaces that incorporate such health-giving attributes as light and nature into the built environment. Today, a growing number of architects are beginning to apply these principles in the design of hospitals and other spaces.

Yuhgo Yamaguchi discusses the current trends in hospital design—light and flora-filled atriums, pavilions that circulate airflow, and patient windows that look out to gardens and trees—and how they have helped reduce bacterial infections and the length of stay.³⁵⁰ A study conducted by the Center for Health Design revealed that people who walk through and spend time in hospital gardens report a therapeutic benefit from simply being in them.³⁵¹ Another study showed that patients who were assigned to a room with a window

³⁴⁷ Anthes, loc. 512.

³⁴⁸ “About EDAC: Evidence-Based Design Accreditation and Certification,” Center for Health Design, accessed July 7, 2020, <https://www.healthdesign.org/certification-outreach/edac/about>.

³⁴⁹ Justin B. Hollander and Ann Sussman, “Why Architecture Education Needs to Embrace Evidence-Based Design, Now,” *Architectural Digest*, November 16, 2018, <https://www.architecturaldigest.com/story/architecture-education-needs-to-embrace-evidence-based-design-now>.

³⁵⁰ Yuhgo Yamaguchi, “Better Healing from Better Hospital Design,” *Harvard Business Review*, October 5, 2015, <https://hbr.org/2015/10/better-healing-from-better-hospital-design>.

³⁵¹ Clare Cooper Marcus and Marni Barnes, *Gardens in the Healthcare Facilities: Uses, Therapeutic Benefits, and Design Recommendations* (Berkeley: University of California, 1995), 71.

view of trees had shorter hospital stays and received fewer medications than a group of patients with rooms that faced a brick building.³⁵²

In Afghanistan, Arcop has created a master plan for a hospital with courtyards to facilitate patient flow and promote tranquility.³⁵³ The architects describe their approach to the design as follows: “Where through natural light and ventilation, views of mountains and gardens and access to outdoor courts, an architecture is created which fosters health and well-being.”³⁵⁴ Another architectural firm, White Architects, designed a hospital in the Democratic Republic of Congo with lots of natural light and green pathways and squares to promote the health of women and children in the maternity unit.³⁵⁵

5. Buildings That Can Breathe

The COVID-19 pandemic has renewed interest in the role that a building’s envelope may play in supporting infection control. The building envelope consists of the walls, foundation, slabs, and roofing that separates the interior of a building from the outdoor environment.³⁵⁶ Current building practices treat the building envelope as an airtight sealed box. “Leaky” buildings are tightened-up in order to lower energy bills.

In a pandemic, opening up a window is a simple way to replace contaminated air with clean air.³⁵⁷ When MASS was brought in to help Mount Sinai repurpose their space to manage a surge in coronavirus patients, their architects found that “it was much easier to jury-rig the dozens of new ICU rooms that were in a 1920s tower with operable windows

³⁵² R. S. Ulrich, “View through a Window May Influence Recovery from Surgery,” *Science* 224, no. 4647 (1984): 420–21, <https://doi.org/10.1126/science.6143402>.

³⁵³ Alyn Griffiths, “Arcop Arranges Afghan Hospital around Public and Private Courtyards,” *Dezeen*, July 25, 2018, <https://www.dezeen.com/2018/07/25/arcop-arranges-afghan-hospital-around-public-and-private-courtyards/>.

³⁵⁴ Griffiths.

³⁵⁵ “Panzi Hospital,” White Arkitekter, accessed November 14, 2019, <https://whitearkitekter.com/project/panzi-hospital/>.

³⁵⁶ Chris Arnold, “Building Envelope Design Guide - Introduction,” *Whole Building Design Guide*, November 8, 2016, <https://www.wbdg.org/guides-specifications/building-envelope-design-guide/building-envelope-design-guide-introduction>.

³⁵⁷ Davidson, “That Office AC System Is Great—at Recirculating Viruses.”

than it was to deal with a sealed-curtain wall tower from the 1960s.”³⁵⁸ According to MASS, the infected air in the 1960s tower had to be “rapidly changed, rigorously filtered, and vented to the outside” to protect patients and healthcare workers from contamination.³⁵⁹

Many architects are now calling for building envelopes that allow “buildings to breathe.”³⁶⁰ From this view, buildings that are more porous are healthier. In June 2020, indoor spaces like bars and restaurants became “super-spreaders” of the coronavirus. Many scientists regard these clusters of infection as evidence that the virus “lingers in the air indoors, infecting those nearby.”³⁶¹ Indoor spaces like bars and restaurants typically lack light and airflow, and bring in little, if any, fresh air from outside.

One strategy to open up a building is to employ a “mixed-mode” ventilation system. This system is set to operate on natural ventilation mode, but it switches over to a mechanical solution if there is insufficient wind to heat, cool, and ventilate a space.³⁶² For example, if the weather is too hot or too cold, the system adjusts the building’s window actuators (to open and close the window) and activates the mechanical ventilation system.³⁶³ A mixed-mode system also allows a building to open and close to optimize IAQ and thermal comfort.

³⁵⁸ Davidson.

³⁵⁹ Davidson.

³⁶⁰ Vikram Prakash, “Architecture in the Time of Coronavirus with Mark Wigley,” in *Architecture Talk*, May 27, 2020, podcast, MP3 audio, 1:01:43, <https://podcasts.apple.com/us/podcast/72-architecture-in-the-time-of-coronavirus-with-mark-wigley/id1232999115?i=1000475991321>.

³⁶¹ Apoorva Mandavilli, “239 Experts with One Big Claim: The Coronavirus Is Airborne,” *New York Times*, July 4, 2020, <https://www.nytimes.com/2020/07/04/health/239-experts-with-one-big-claim-the-coronavirus-is-airborne.html>.

³⁶² “About Mixed Mode Ventilation,” State of Green, accessed July 4, 2020, <https://stateofgreen.com/en/partners/windowmaster/solutions/about-mixed-mode-ventilation/>.

³⁶³ “Natural and Mixed Mode Ventilation,” Window Master, accessed July 4, 2020, <https://www.windowmaster.com/solutions/mixed-mode-ventilation>.

B. MAKING CITIES MORE LIVABLE AND RESILIENT

This section examines strategies to manage density better in cities by diversifying the typology of buildings, and by reclaiming public space for pedestrian-friendly activities. It also discusses strategies to make cities more livable and resilient.

1. Distributing Density

In recent years, there has been a significant increase in the number of high-rise buildings that are being constructed in cities.³⁶⁴ Some of this growth is being driven by urbanization—high-rises are being built in places like Mumbai to accommodate rapid population growth. New technology in the form of “sophisticated computer modeling has also allowed developers to design taller and narrower buildings on sites that used to require wider bases.”³⁶⁵ Another key driver is economics: the residential housing market for high-rises is extremely lucrative. For example, in New York City, more than 50 new buildings have begun rising over 700 feet tall in Lower and Midtown Manhattan.³⁶⁶ These buildings have transformed the city’s skyline.

High-rise buildings house a large number of people in one space. In a high-rise, people live in close proximity to one another, which puts them in close range for respiratory viruses like COVID-19. High-rise buildings also create a number of social interactions—sharing elevators and laundry rooms—that congregate people together. The risk of contamination is also elevated from the number of high-contact surfaces like doorknobs, elevator buttons, and washing machines. Some in the building industry are calling for high-touch surfaces to be replaced by voice or motion-activated interfaces.³⁶⁷

³⁶⁴ “‘Mini Cities’: The Rise of Tall Buildings,” Smart Cities World, accessed May 1, 2020, <https://www.smartcitiesworld.net/opinions/opinions/mini-cities-the-rise-of-tall-buildings>.

³⁶⁵ Azi Paybarah, “How a Luxury Boom Is Changing New York’s Skyline,” *New York Times*, June 6, 2019, <https://www.nytimes.com/2019/06/06/nyregion/newyorktoday/nyc-skyline-real-estate.html>.

³⁶⁶ Paybarah.

³⁶⁷ Cait Etherington, “High-Rise Urban Living and COVID-19: What Are the Risks and Can We Design Pandemic-Proof Buildings?,” City Realty, June 12, 2020, <https://www.cityrealty.com/nyc/market-insight/features/future-nyc/high-rise-urban-living-covid-19-what-risks-can-we-design-pandemic-proof-buildings/43581>.

Giving high-rise dwellers a voice or motion-activated-type command to run an elevator seems like a good start. But, such a measure fails to address the real issue of maintaining the housing supply while diversifying it. Today's pattern of high-density developments on small lot sizes has made communities more vulnerable to infectious disease.³⁶⁸ High-rises and towers have also become attractive targets for both domestic and international terrorism.

An emerging strategy to mitigate this risk is to “plan for more distributed density throughout the urban footprint, using a variety of building typologies and a range of densities.”³⁶⁹ In a conversation with Meghna Chakrabarti on NPR, Ken Greenberg discussed how cities can “distribute density” better by building more mid-rise buildings (five to eleven stories tall), along with walk-up units and duplexes.³⁷⁰ In addition, garden-style apartments also hide density by siting units in the back of a development or along a laneway. Greenberg is an urban designer and former director of architecture for the City of Toronto.

For Greenberg and others, planning for “better density” involves promoting a wider mix of housing options, moving beyond the predominant developments of high-rises and single-family homes. This movement recalls the work of Jane Jacobs who became an ambassador for mixed-use developments that combined various housing types with retail set at the street level. Some cities have begun to adopt these strategies already. The City of Minneapolis recently amended their zoning code to convert lots zoned for single-family to allow for multi-family housing options.³⁷¹ By amending land-use classifications, cities may be able to disperse the built environment by providing more housing options. Borrowing a page from *New Urbanism*, these strategies also reference the *Town Square*

³⁶⁸ Ryerson City Building Institute, *Density done Right* (Toronto: Ryerson City Building Institute, 2020), 3, <https://www.citybuildinginstitute.ca/portfolio/density-done-right/>.

³⁶⁹ Ryerson City Building Institute, 9.

³⁷⁰ Adam Waller and Meghna Chakrabarti, “Cities That Heal: How the Coronavirus Pandemic Could Change Urban Design,” in *On Point*, April 28, 2020, podcast, MP3 audio, 47:10, <https://www.wbur.org/onpoint/2020/04/28/coronavirus-pandemic-change-evolution-of-cities-and-urban-design>.

³⁷¹ Ryerson City Building Institute, *Density Done Right*, 29.

approach, connecting smaller-scale units and mid-rises to greenspaces, playgrounds, and parks, and “streets turned over to pedestrians.”³⁷²

2. Reclaim Public Space

Making cities more resilient to disease will also involve making them more livable. On a normal day, walking along a New York City sidewalk can be an adventure. As Caroline Spivack writes for Curbed New York, New York City’s “skinny sidewalks are packed with tree pits, benches, and bus shelters, turning a simple walk into a sort of obstacle course for New Yorkers.”³⁷³ During the pandemic, the city’s narrow sidewalks made it extremely difficult to maintain six feet of distance from other pedestrians. Walking down the street became a threat to health. In the post-COVID-19 era, urban planners in New York City and other metropolitan areas could widen sidewalk zones, giving pedestrians more through space to walk in, and more space between the through zone and curb zone.³⁷⁴

Urban planners can also close streets permanently to accommodate pedestrians and cyclists. The reclaimed space can be used to promote movement and activity. During the COVID-19 outbreak, subway ridership in New York City declined as many people stayed home or walked or cycled to work. It is likely that many businesses and government offices will continue to operate remotely after the country “re-opens” after COVID-19 is contained.³⁷⁵ To maintain social distancing after the pause is lifted, many people are likely to continue teleworking or to work in staggered shifts. Access to bike paths and walkways will be more important than ever for residents to stay active and to travel to work and school.

³⁷² Sam Lubell, “Commentary: Past Pandemics Changed the Design of Cities. Six Ways COVID-19 Could Do the Same,” *Los Angeles Times*, April 22, 2020, <https://www.latimes.com/entertainment-arts/story/2020-04-22/coronavirus-pandemics-architecture-urban-design>.

³⁷³ Caroline Spivack, “New York City Sidewalks Have Failed Us. Here’s How We Can Fix Them,” *Curbed New York*, April 23, 2020, <https://ny.curbed.com/2020/4/23/21231798/coronavirus-nyc-sidewalk-widths-pedestrians-biking>.

³⁷⁴ “Sidewalks,” National Association of City Transportation Officials, July 11, 2013, <https://nacto.org/publication/urban-street-design-guide/street-design-elements/sidewalks/>.

³⁷⁵ Jack Kelly, “Here Are the Companies Leading the Work-from-Home Revolution,” *Forbes*, May 24, 2020, <https://www.forbes.com/sites/jackkelly/2020/05/24/the-work-from-home-revolution-is-quickly-gaining-momentum/#5bb5fba41848>.

Parking spaces can be reclaimed for restorative plazas, parks, or landscaping. This space can also be used for outdoor seating and dining. The city of San Francisco is considering a plan to reclaim underutilized parking spaces and garages for affordable housing, parks, and pedestrian amenities.³⁷⁶ Going forward, urban planners can make cities healthier by taking space back from cars and turning it over to pedestrians.

Urban planners can also make cities more livable by encouraging developers to build balconies in multi-unit buildings.³⁷⁷ During the sanitarium movement, architects incorporated balconies into their designs in order to connect people with fresh air and sunshine. Today, many zoning laws restrict the amount of space that developers may use for balconies and terraces.³⁷⁸ By making these laws more flexible, urban planners can incentivize developers to build more balconies, and to make them larger.

C. CONCLUSION

In Pittsburgh, Pennsylvania, Gensler built a 33-story tower that uses sensors and vertical vents to open the building envelope to bring in fresh air.³⁷⁹ According to Gensler, the tower “relies on natural ventilation for 42 percent of the year.”³⁸⁰ During the winter, the sensors close the envelope, and use various systems to “passively warm the interior.”³⁸¹ The tower houses PNC Bank’s headquarters. It opened in 2015.

The PNC Tower and House Zero demonstrate that natural ventilation systems can be incorporated into a variety of building typologies. Architects can create spaces that breathe, and that are integrated with the natural environment outside. The WELL Living

³⁷⁶ Smart City Challenge, “San Francisco: Harnessing the Future of Shared Mobility” (fact sheet, Smart City Challenge, 2016), https://www.sfmta.com/sites/default/files/projects/2016/Smart_City_Fact_Sheet.pdf.

³⁷⁷ Linda Poon, “Lesson from Coronavirus: Build Better Balconies,” Bloomberg CityLab, April 20, 2020, <https://www.bloomberg.com/news/articles/2020-04-20/lesson-from-coronavirus-build-better-balconies>.

³⁷⁸ Poon.

³⁷⁹ Nate Berg, “Award: The Tower at PNC Plaza,” *Architect*, July 15, 2016, https://www.architectmagazine.com/awards/r-d-awards/award-the-tower-at-pnc-plaza_o.

³⁸⁰ Berg.

³⁸¹ Berg.

Lab shows that spaces can be designed to monitor such environmental variables as CO₂, humidity, and temperature—variables that can keep people healthy or make them sick. Architects can also create spaces that are flexible and that may be adapted over time as needs arise. Buildings can learn, and they can also protect people from exposure to contaminants.

Architects and urban planners can also design buildings and communities to manage density better, and to make them more resilient. By creating spaces that prioritize health-giving attributes—through the circulation of airflow, spatial design, biophilic elements, natural light, and in selecting the right building materials—architecture can be built for healing, and to control the spread of disease.

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V. PRESCRIPTIONS FOR HEALTHY BUILDINGS AND RESILIENT SPACES

In “The Magic of Empty Streets,” Allison Arieff writes that as a result of COVID-19, “Health and safety concerns may supersede all others for a long time.”³⁸² During the lockdown, many millions of people spent weeks and months at home. Their home became a place for work, school, and recreation. Being able to access fresh air and sunlight from home, or to have a view of nature, seemed more important than ever.

Eventually, the country and the world community will “re-open” after COVID-19 is contained. But, as Arieff suggests, the possibility of the virus flaring back up or being followed by another virus remains high. The world community must take steps today to make spaces healthier, and more resilient to disease. Architecture can play an important role in supporting infection control. Specifically, in the post-COVID-19 era, there is an opportunity to make homes and spaces healthier, and to design out pollutants and pathogens that make people sick. Through an attention to light, airflow, and nature, building materials, and spatial literacy, an architecture can be created that promotes healing.

This chapter surveys the current landscape within the healthy building certification market. It then prescribes a new certification program that aims to be pandemic-resistant. This chapter also discusses how the architecture, urban planning, and public health fields can work together to implement, promote, and validate healthy building standards and processes.

A. THE HEALTHY BUILDING LANDSCAPE

In *Healthy Buildings: How Indoor Spaces Drive Performance and Productivity*, Allen and Macomber write favorably about the development of the WELL Building Standard to promote wellness in the built environment.³⁸³ The WELL Building Standard

³⁸² Allison Arieff, “The Magic of Empty Streets,” *New York Times*, April 8, 2020, <https://www.nytimes.com/2020/04/08/opinion/coronavirus-tips-new-york-san-francisco.html>.

³⁸³ Allen and Macomber, *Healthy Buildings*, loc. 3180.

was created by Paul and Pete Scialla, two brothers with experience in finance, who, according to Allen and Macomber, saw the “immense potential of combining two of the largest sectors in the U.S. economy—real estate and health care.”³⁸⁴ Through this lens, designing and constructing healthy buildings makes good business sense. When WELL was founded in 2014, the market for healthy buildings was beginning to grow. At the time, companies began to see that tenants and clients were willing to pay more in rent for healthy indoor spaces.³⁸⁵ Building owners who could hang a framed healthy building certificate in the lobby also commanded higher occupancy rates. In the post-COVID-19 world, the market for healthy buildings is likely to grow even stronger as more employees, tenants, homeowners, and students demand to work, live, learn, and play in healthier environments.

Like Fitwel, the WELL Building Standard invites architects, developers, and building operators to register projects for healthy building certification. After a project is registered, both Fitwel and WELL assign a team of accredited professionals (APs) to work with an applicant’s project team to develop and implement health-promoting strategies at the site.³⁸⁶ Leveraging their backgrounds in health and wellness, the APs apply a checklist to assign a rating for each project. In general, the APs give out points based on the number of items an individual project is able to check off. For Fitwel and WELL, the checklist focuses on such wellness attributes as sound acoustics, nutrition, water quality, mood, recreation, and fitness.³⁸⁷ Depending on a numerical score, a project may earn various levels of certification status.

Building owners and operators are willing to pay fees and to make changes to a project’s design in order to get a certification. It is clear that earning a certificate has monetary value. Whether it is through LEED (green building and energy conservation), CPTED (crime prevention and public safety), or Fitwel and WELL (health and wellness),

³⁸⁴ Allen and Macomber, loc. 3180.

³⁸⁵ Allen and Macomber, loc. 3524.

³⁸⁶ “About the WELL AP Exam,” International WELL Building Institute, accessed May 31, 2020, <https://www.wellcertified.com/well-ap/exam>.

³⁸⁷ Fitwel, “Who We Are.”

good building design can be promoted, validated, and implemented with the support of independent credentialing organizations.

Of course, building healthy environments is not just good for business. It is good for public health. Up until now, the healthy building movement has focused primarily on active design and *acceptable* IAQ. Considering that most people spend 90 percent of their time indoors, the value of this work cannot be understated.³⁸⁸ Study after study has shown that indoor air pollutants alone can lead to adverse health effects, including: respiratory diseases, heart disease, cancer, and sick building syndrome.³⁸⁹ But, today, a building operator can get points for IAQ for simply having a plan without an independent verification of the air quality in the space. It is like having a fire safety plan without fire protection systems like alarms, sprinklers, and extinguishers.³⁹⁰

In the post-COVID-19 world, there is an opportunity to expand the focus of certification programs like these beyond active design and wellness. As Allen and Macomber, and organizations like NAFA note, acceptable IAQ levels are not the same as healthy IAQ.³⁹¹ By recalibrating priorities and standards, a certification program could support the design of the built environment to help reduce the transmission of respiratory viruses like COVID-19.

For example, take Fitwel, which is run by two federal agencies—the Centers for Disease Control and Prevention and the General Services Administration. Combined, these agencies influence the worlds of public health and real estate. If Fitwel were to raise its standards for IAQ above the minimum—and create new categories for building materials, contact surfaces, spatial literacy, ventilation, and air filtration—it could influence the entire healthy building certification market. By encouraging and promoting these higher

³⁸⁸ Day, *Places of the Soul*, 164.

³⁸⁹ “Indoor Air Quality,” Environmental Protection Agency, accessed August 29, 2020, <https://www.epa.gov/report-environment/indoor-air-quality>.

³⁹⁰ “Evacuation Plans and Procedures eTool,” Occupational Safety and Health Administration, accessed June 8, 2020, <https://www.osha.gov/SLTC/etools/evacuation/fire.html>.

³⁹¹ Allen and Macomber, *Healthy Buildings*, loc. 1227.

standards to make them more pandemic-resistant, Fitwel could in turn produce secondary benefits for addressing chronic conditions like asthma and diabetes.

B. MEET DR. WELLBE.

There is an opportunity now to create a building certification program that aims to be pandemic-resistant. This program requires higher standards for ventilation, air-filtration, and IAQ than programs like WELL and Fitwel, and encourages other health-promoting strategies in the design and operation of the built environment. This program is called disease resilience and wellness in the built environment (Dr. Wellbe.).

The idea for a new certification program began to take shape the more I read about the role that airflow, light, spatial design, nature, and the treatment of materials can play in infection control. I created Dr. Wellbe. (see Figure 6) to promote design standards that are more resilient than the current market, and that can protect the public during a pandemic. Tables 1 through 5 outline the core strategies, and Figure 7 depicts the components of the program.



Disease Resilience and Wellness in the Built Environment

Figure 6. Logo for Dr. Wellbe.

Table 1. Engage with Nature

Icon	ID	Sub-Title	Strategy
	1.0	Create Restorative Spaces ³⁹²	Provide occupants with access to outdoor gardens, courtyards, nature trails, walkways, and open space.
	1.1	Views of Nature	Provide occupants with views of the natural environment through a building's windows and openings.
	1.2	Indoor Restorative Spaces	Provide occupants with access to such indoor biophilic elements as an atrium with plants and trees.
	1.3	Indoor Views of Nature	Provide occupants with access to nature-themed art and imagery.
	1.4	Terraces and Balconies	Provide occupants with access to terraces and balconies, if possible, to connect them to nature and fresh air.

³⁹² The title, "Create Restorative Spaces," is based on attention restoration theory.

Table 2. Make Spaces Breathe Better

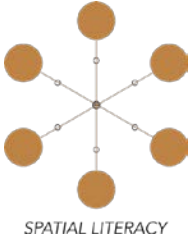
Icon	ID	Sub-Title	Strategy
	1.0	Operable Windows	Provide occupants with access to operable windows.
	1.1	Ventilation Rates	Establish a minimum standard for ventilation rates for commercial spaces to 40 cubic feet per minute per person. ³⁹³
	1.2	Relative Humidity	Establish such systems as sensors and software to monitor and maintain relative humidity levels of 40–60 percent. ³⁹⁴
	1.3	Indoor Air Quality (IAQ)	Establish such systems as sensors and software to test and monitor temperature and CO ₂ levels regularly, along with VOCs and particulate matter (PM).
	1.4	Natural Ventilation Systems	Employ the forces of wind and buoyancy for heating and cooling, and to bring in air from outside.
	1.5	Airflow and Cross-Ventilation	Employ windows, louvers, ducts, and other openings in the building envelope, along with high ceilings and fans, to maximize airflow and cross-ventilation.
	1.6	Redundant Ventilation Systems	Employ either passive or mechanical ventilation systems, depending on the seasons or climate, and/or the needs of occupants.
	1.7	Air Filtration	Installation of high-efficiency filtration systems (MERV 13 or higher) to remove particulate matter (PM), VOCs, and airborne pathogens in indoor spaces. ³⁹⁵
	1.8	Germicidal Ultraviolet Units (GUVs)	Installation of GUV units in the ducts of mechanical ventilation systems.

³⁹³ The recommendation to double the ventilation rate from the ASHRAE standard is based on studies by Allen and Macomber that showed doubling the rate increases cognition and problem-solving skills in office environments.

³⁹⁴ The relative humidity levels are based on a NIOSH study that showed indoor humidity levels play an important role in the infectivity of aerosolized droplets.

³⁹⁵ This recommendation is based on the American Institute of Architects' *Re-Occupancy Assessment Tool*. A MERV 13 filter removes at least 90 percent of PM in a space.

Table 3. Make Spaces More Spatially Literate

Icon	ID	Sub-Title	Strategy
	1.0	Wayfinding Systems	Employ such wayfinding systems as signage, visual cues, maps, and paths to guide occupants through a space. This includes using visual cues and signage to sequence the flow of occupants through a space to reduce congestion and density (for example: in hallways and waiting areas).
	1.1	Create Zones to Reduce Contamination	Create separate changing and storage areas for donning and doffing PPE (for example: in hospitals and restaurants). ³⁹⁶
	1.2	Create Spaces that are Defensive	Employ such physical barriers as plexiglass and partitions to maintain safe distancing in offices, retail establishments, schools, and other spaces.
	1.3	Safe Distancing	Employ such visual cues as tape and markings to maintain safe distancing in groceries, retail establishments, and other spaces.
	1.4	Adaptable Spaces	Create space and components that may be adapted for other purposes.

³⁹⁶ This recommendation is based on MASS Design Group’s fact sheet titled “Spatial Strategies for Restaurants in Response to COVID-19.”

Table 4. Building Materials and Contact Surfaces Matter

Icon	ID	Sub-Title	Strategy
	1.0	Copper Alloys and Surfaces	Use copper alloys and surfaces (and/or other approved antimicrobials) on such high-contact surfaces as door knobs, faucets, handrails, sinks, and workstations. ³⁹⁷
	1.1	Volatile Compound Reduction ³⁹⁸	Manage the level of VOCs in furniture, flooring, paints, wall coverings, and insulation.
	1.2	Touch-Free Systems	Use touch-free and/or motion-activated systems for lighting, entry (for example: in elevators), and to operate equipment and accessories. ³⁹⁹
	1.3	Cleaning Products ⁴⁰⁰	Establish a policy to purchase low hazard cleaning products.
	1.4	Water Quality and Contamination Control	Monitor and test water quality for drinking. Implement a legionella management plan to control risks. ⁴⁰¹

³⁹⁷ Infection Control Today, “EPA Approves Registration of Antimicrobial Copper Alloys.” This recommendation is based on the EPA’s registration of copper alloys and surfaces with “public health claims.”

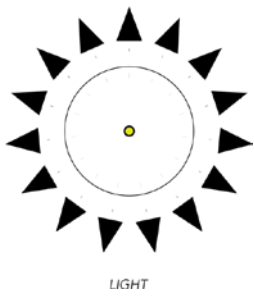
³⁹⁸ “WELL v2 Pilot,” WELL Building Institute, accessed July 20, 2020, <https://v2.wellcertified.com/v/en/overview>. This recommendation is from the WELL v2 pilot program on volatile compound reduction.

³⁹⁹ This recommendation is based on the American Institute of Architects’ *Re-Occupancy Assessment Tool*.

⁴⁰⁰ This recommendation is from the WELL v2 pilot program on cleaning products and protocols.

⁴⁰¹ This recommendation is from the WELL v2 pilot program on legionella control.

Table 5. Health-Giving Light

Icon	ID	Sub-Title	Strategy
	1.0	Natural Light and Daylighting	Employ windows and openings in the building envelope to provide occupants with access to natural light.
	1.1	Circadian Lighting Design ⁴⁰²	Employ a circadian lighting design in indoor spaces that mimics the rhythms and patterns of the natural environment (blue hues during the day and yellow hues at night).
	1.2	Atriums, Skylights, and Window Views	Organize indoor spaces (workspaces, patient rooms) to maximize exposure to sunlight.
	1.3	Glazing	Employ glass and other translucent materials to maximize access to natural light.

⁴⁰² This recommendation is from the WELL v2 pilot program on circadian lighting design.

Dr. Wellbe.

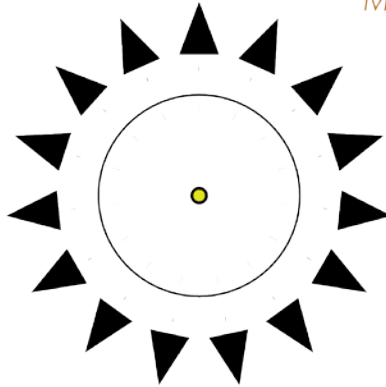
Disease Resilience and Wellness in the Built Environment



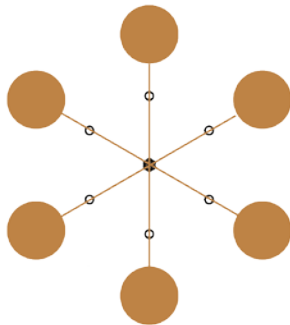
AIRFLOW AND FRESH AIR



MATERIALS MATTER



LIGHT



SPATIAL LITERACY



NATURE

Figure 7. Dr. Wellbe. Concept

In light of my research, I created Dr. Wellbe. to promote design standards and practices that are more resilient than the current market. Specifically, Dr. Wellbe. requires higher standards for airflow, the treatment of building materials, spatial planning, light, and nature than certification programs like LEED, Fitwel, and WELL. Going forward, Dr. Wellbe. can support infection control in buildings, offices, hospitals, schools, homes, and other spaces. By encouraging and promoting these higher standards to make them more pandemic-resistant, Dr. Wellbe. can also produce secondary benefits for addressing chronic conditions like asthma and diabetes.

C. RECONNECT THE ARCHITECTURE AND URBAN PLANNING FIELDS WITH PUBLIC HEALTH

The reintegration of the architecture, urban planning, and public health fields is needed to reimagine how buildings and communities are designed. Combined, the fields bring together the worlds of health science, building science, urban design, and city planning. This lens gives the fields a unique perspective on emerging health risks, and in developing strategies to mitigate risk and protect the public.

The COVID-19 pandemic reaffirmed how interconnected the built environment is with public health. During the pandemic, every space became a medical space.⁴⁰³ Overnight, a global conversation emerged about the role that individual spaces may play in either containing or transmitting the virus. To a great extent, the public turned to scientists, architects, and civic leaders to help them identify such high-risk areas as indoor spaces, and to navigate them more safely.

As offices and retail establishments began to reopen, many spaces were reconfigured to make them more defensive—with plexiglass and barriers—and by using visual cues like tape and markings to maintain safe distancing. Architects refer to these strategies as “spatial literacy,” in which various systems are employed to help the public read and understand space. Going forward, it will be important for the fields to refine and promote these systems to help the public inhabit spaces safely.

⁴⁰³ Prakash, “Architecture in the Time of Coronavirus.”

Before the pandemic, design strategies had been employed to promote energy conservation, crime prevention initiatives, and wellness activities. The fields have a key role now in expanding these strategies to make the built environment healthier, and to make it more disease resilient. This role will include encouraging building practices that elevate such health-promoting attributes as light, airflow, and nature, and the treatment of building materials, into the built environment.

Going forward, the fields will need to work together to hold the building industry accountable to healthy building standards and practices. This may involve adopting and enforcing more stringent building codes on IAQ, ventilation rates, and building materials. To test building performance, a third-party inspection system seems warranted to ensure compliance with the new codes.

In July 2020, a group of business leaders in New York City floated the idea to apply the Health Department's grading system for restaurants (grades are assigned based on food safety) to assess building safety during COVID-19.⁴⁰⁴ The group's report provides few details, but is an interesting model to explore. For example, the model can be applied to monitor indoor air quality in the following manner. The fields can partner to conduct inspections to test and measure pollutants (VOCs) and CO₂ levels in a building or indoor environment. During the inspection, a team of health scientists, architects, and engineers can develop an IAQ Wellness Score that corresponds to healthy building standards. The fields can require building owners to display the score in the lobby of their building.

The fields also have an important role to play in engaging the public to promote healing design strategies and goals. These outreach efforts will involve reaching out to homeowners, tenants, workers, and students and communicating how the built environment affects their health. For example, buildings that are not performing well increase occupants' exposure to indoor pollutants and pathogens that can make them sick. Poor IAQ is shown to affect productivity, cognition, and well-being in office spaces, and quality of care and patient outcomes in hospital settings. If the public can be mobilized as

⁴⁰⁴ Partnership for New York City, *A Call for Action and Collaboration* (New York: Partnership for New York City, 2020), 24, <https://pnyc.org/wp-content/uploads/2020/07/actionandcollaboration.pdf>.

a partner in the healthy building movement, they can help shape policies and standards that promote healing.

D. RECOMMENDATIONS BY STAKEHOLDER

Today, architects, planners, and engineers are designing spaces to withstand natural disasters like earthquakes and hurricanes.⁴⁰⁵ In the post-COVID-19 era, spaces can be designed to protect the public during a pandemic, and to promote wellness and infection control. Healthy buildings can become the industry standard, built to learn and adapt over time, and to deliver light, nature, and clean air to occupants. Dr. Wellbe. can pave the way forward, creating a more resilient brand of architecture, in which health-giving attributes shape the spaces people live, learn, and play in. The following recommendations aim to convert these strategies into concrete building standards, processes, and practices.

1. Governments

- Enact federal legislation to encourage state and local governments to adopt and enforce healing design building codes as a key strategy for making communities more resilient to disease.
- Create a rating system and inspection program to assess and monitor IAQ levels in indoor spaces.
- Incorporate the fields of urban planning and architecture into homeland security-related planning and preparedness activities.

2. Certification Programs

- Following the LEED, WELL, and Fitwel programs, create a stand-alone healing design certification program (Dr. Wellbe.) to encourage architects,

⁴⁰⁵ Thomas Fuller et al., “Buildings Can Be Designed to Withstand Earthquakes. Why Doesn’t the U.S. Build More of Them?,” *New York Times*, June 7, 2019, <https://www.nytimes.com/interactive/2019/06/03/us/earthquake-preparedness-usa-japan.html>.

developers, design teams, and building managers to design and retrofit spaces with health-giving attributes.

- Enhance the existing standards for ventilation and IAQ across all of the building certification programs.

3. The Building Industry, Including Building Owners and Operators

- Increase the minimum standard for ventilation rates for commercial spaces (ASHRAE's Ventilation for Acceptable Indoor Quality) to 40 cubic feet per minute per person. The current ASHRAE standard is 20 cubic feet per minute per person.
- Encourage building owners and operators to utilize high-efficiency filtration systems (MERV 13 or higher) to remove particulate matter (PM), VOCs, and airborne pathogens in indoor spaces. According to NAFA, a MERV 13 filter removes at least 90 percent of PM in a space.⁴⁰⁶ The costs to upgrade filters are minimal.
- Encourage building owners and operators to monitor relative humidity, temperature, and CO₂ levels regularly.

4. Urban Planning and Policymakers

- Reconnect the fields of urban planning, architecture, and public health through educational curriculums, professional development workshops, and professional associations (example: American Planning Association and American Institute of Architects).
- Make cities more livable by widening sidewalks to accommodate safe distancing, and by closing streets to promote pedestrian-friendly activities. Create more bike paths and walkways to promote movement and activity.

⁴⁰⁶ National Air Filtration Association, "Understanding MERV."

Amend local zoning regulations to encourage eating and drinking establishments to create more outdoor sidewalk cafes.

- Amend local zoning regulations to encourage architects and developers to design and build more terraces and balconies in apartment dwellings and units. By incorporating terraces and balconies into a building's design, architects can connect occupants with fresh air and natural light.
- Urban planners should consider amending local land-use ordinances to encourage a more diverse typology of housing options. The goal of these efforts should be to distribute density in major cities through a mix of mid-rise buildings, multi-family units, and garden and laneway apartments.
- Amend local land-use ordinances and building codes to encourage building design that is more flexible and adaptable.

E. CONCLUSION

The thesis began by outlining a series of risk factors—zoonosis, globalization, urbanization, and land use—that will increase the frequency and intensity of disease outbreaks in the years to come. As COVID-19 has shown, an outbreak can occur at any time. Architecture can be an agent to help reduce the risk, and to make communities more resilient to disease.

In the 19th century, cities like London, New York, and Paris implemented housing reforms to improve the living conditions in tenements and other dwellings. This period coincided with a broad sanitary movement to shape urban form to make it healthier. The incorporation of light, nature, and airflow into a building's design was seen as a prescription for sickness and disease.

In recent years, a growing body of research is confirming what the architects and planners from the past knew from theory and intuition: that the built environment can play an important role in promoting health and well-being. Studies show that the built environment affects cognition, productivity, and wellness in office spaces, and the quality

of care in hospitals and healthcare settings. Studies by the Lawrence Berkeley National Laboratory show that the air quality in a space may either harbor or dilute airborne pathogens that can make people sick.⁴⁰⁷

People spend 90 percent of their time indoors.⁴⁰⁸ Being able to optimize IAQ can significantly promote healing. Strategies to improve IAQ involve replacing contaminated air with clean air, and by using the right building materials. Researchers at the Well Living Lab and House Zero are using emerging technologies to prove that these strategies work, and that they play a key role in health and wellness.

COVID-19 has reaffirmed how the spaces we inhabit can either protect people or make them sick. COVID-19 has also shown how outbreaks of disease are spatial problems. As a field, architecture is well-suited to design spaces that reduce the public's exposure to contamination. With the right building materials, airflow, and spatial strategies, spaces can be designed to support infection control.

In recent years, organizations like MASS Design Group and ARCHIVE Global have been applying these principles to design and build spaces that promote healing. The present thesis examined their work, reviewing each organization's mission and approach to design, along with their core strategies. Their work shows that healing design strategies can be scaled and replicated in a variety of environments.

Ultimately, this thesis advances a prescriptive model to shape the built environment to make it healthier. The model is called disease resilience and wellness in the built environment. It goes by the acronym Dr. Wellbe. The foundation of the model is five health-giving design attributes—light, airflow, nature, building materials, and spatial literacy. These are the design attributes that defined the sanitarium movement, and that feature prominently in the work of MASS and ARCHIVE.

In the post-COVID-19 era, there will be an opportunity to prioritize health-giving attributes in the design and operation of the built environment. The fields of urban

⁴⁰⁷ Fisk, Black, and Brunner, "Benefits and Costs of Improved IEQ in U.S. Offices."

⁴⁰⁸ Day, *Places of the Soul*, 164.

planning, architecture, and public health will have a key role to play in implementing, promoting, and monitoring healing design strategies and goals. The fields also have an important role to play in making communities more livable, healthy, and resilient.

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