# Bridging the Gaps between Public Health and Architecture: A Research Agenda for Architectural Epidemiology

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**Buildings are critical to both sides of the climate crisis. They are both major contributors to global greenhouse gas (GHG) emissions and the primary place of refuge for occupants when climate-fueled disasters strike. Recent research into the public health effects of climate change emphasizes the importance of taking a co-benefits approach to interventions precisely because of the interrelated nature of the causes and consequences of climate change.**

**What is needed is a systematic method for translating research on the health effects of climate change and other public health priorities like chronic disease into actionable design strategies that are tailored to the environmental exposures and population health needs of a specific building project. The conceptual model for a new, transdisciplinary subfield called architectural epidemiology presents building design and facility operations as mediators between the built environment determinants of health and population health outcomes (both positive and negative).**

**While the public health literature is accumulating an increasingly robust body of evidence on the ways in which the built environment mediates exposure to extreme heat, flooding, natural disasters, air pollution, and vector-borne diseases, research on which design and operations strategies are most protective in the face of these events is sparse. Similarly, epidemiological studies on the links between building design and community health priorities like asthma, mental health, obesity, heart disease, and cancer seek to explain disparities in disease prevalence and health outcomes, but fall short of providing actionable information to designers. This paper uses the architectural epidemiology conceptual framework to map out how current epidemiological and architectural research complement each other. It also identifies research gaps in both fields and proposes a transdisciplinary research agenda.**

## THE CHALLENGE

Buildings are critical to both sides of the climate crisis. They are both major contributors to global greenhouse gas (GHG) emissions[1] and the primary place of refuge for occupants when climate-fueled disasters strike. Recent research into the public health effects of climate change emphasizes the importance of taking a co-benefits approach to interventions like building design precisely because of the interrelated nature of the causes and consequences of climate change.[2]

It is therefore important to design buildings that respond to both their environmental and social context. After all, whenever a building is renovated or constructed, it not only changes the surrounding ecological system. It also fits into a social system that manages utilities (i.e., provision of drinking water, electricity, sewer service, waste management, etc.) and controls access to jobs, schooling, medical care, food, parks, and other aspects of civic life.

One way to think about the relationship between building design and the surrounding social systems is to consider how the public approvals process could be described using a framework from the social sciences called the social ecological model[3] (Figure 1). The idea behind this framework is that individuals

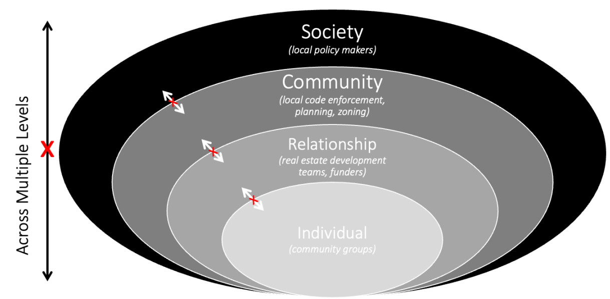


Figure 1. The Social-Ecological Challenge Faced by Building Design Projects. Image adapted from U.S. ATSDR Principles of Community Engagement. 2nd Ed. https://www.atsdr.cdc.gov/communityengagement/pce_models.html

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| Epidemiology | Environmental Epidemiology | Social Epidemiology |
|---|---|---|
| The study of disparities in the distribution of health outcomes across populations (distinguished from clinical care, which focuses on individual health outcomes) | Tracks the pathway(s) from an environmental exposure (positive or negative) to a health outcome. | Considers elements of human society (i.e., cultural customs, laws, socioeconomic structures and systems, etc.) that contribute to positive and negative health outcomes across populations. |

Table 1. Components of Architectural Epidemiology Drawn from Other Epidemiological Subfields

behave differently when they interact with different levels of society. In other words, the same individual might act differently with members of their family than with neighbors. Their behavior would change again when interacting with a colleague or a boss in a professional setting, with the local permitting office, etc. It is important to understand the way motivating forces shift from one level of the social-ecological model to the next, so that architects, owners, and their collaborators can work to overcome the barriers to collaboration and coordination that currently stand in the way of the three levels of society that need to work together to successfully complete a development project: community members, the development team, and local government.

The current system does not incentivize projects to catalyze a positive climate, health, and equity ripple effect in the surrounding neighborhood. Instead, financing and regulations focus attention inside the property line, and do not pay attention to how the proposed project will change exposure to urban heat island, flooding, air pollution, access to sidewalks and parks and healthy foods, or other community characteristics that may be high priorities for the people who currently live, work, and own property in the surrounding neighborhood.

This article proposes a new approach to architectural research and practice that reorients the role of design from focusing exclusively inside the property line to maximizing a project's beneficial impact on the surrounding community. It draws on a book that this article's author Houghton is co-authoring with Dr. Carlos Castillo-Salgado, a professor at Johns Hopkins Bloomberg School of Public Health. The book, *Architectural Epidemiology*, proposes a new, transdisciplinary subfield that attempts to bring the two fields in its name together in support of that shift in perspective.

## A PROPOSED SOLUTION: ARCHITECTURAL EPIDEMIOLOGY

The idea behind the proposed new transdisciplinary subfield, architectural epidemiology, is that architectural design could be used proactively as a mechanism for promoting community health, because it influences population health outcomes regardless of whether or not the designer intends it to do so.

Table 1 displays the elements of epidemiology that contribute to the architectural epidemiology conceptual framework. The overarching field of epidemiology studies and attempts to measure disparities in the distribution of health outcomes across populations. It includes many subfields. But, the two primary influences on the development of architectural epidemiology are environmental epidemiology and social epidemiology. Research in environmental epidemiology tends to focus on exposure pathways. For example, if a child diagnosed with asthma is playing at home in her room, how would particles emitted by diesel trucks on the freeway a block from her house enter her body and trigger an asthma attack? Social epidemiology, on the other hand, asks a different question: How have social, economic, and/or political forces led to the construction of the freeway in that neighborhood; the construction of housing that might expose vulnerable groups like young children to environmental asthma triggers; and, the race, ethnicity, and socioeconomic groups that are more likely to live near the freeway?

The architectural epidemiological conceptual model[4] (Figure 2) combines environmental epidemiology (dark grey top half of the diagram) and social epidemiology (light grey bottom half of the diagram) into a coherent picture of the mechanism by which architectural design could act as a mediator between environmental exposures and health outcomes.

Starting on the left side of the diagram, the question of which environmental hazards are relevant to a proposed real estate development project could be divided into two parts. The first box asks the development team to investigate whether any environmental hazards like heat waves, flooding, air pollution, wildfire, and mosquito-borne pathogens are likely to be present on and around the building site. Answering that question falls within the scope of environmental epidemiology.

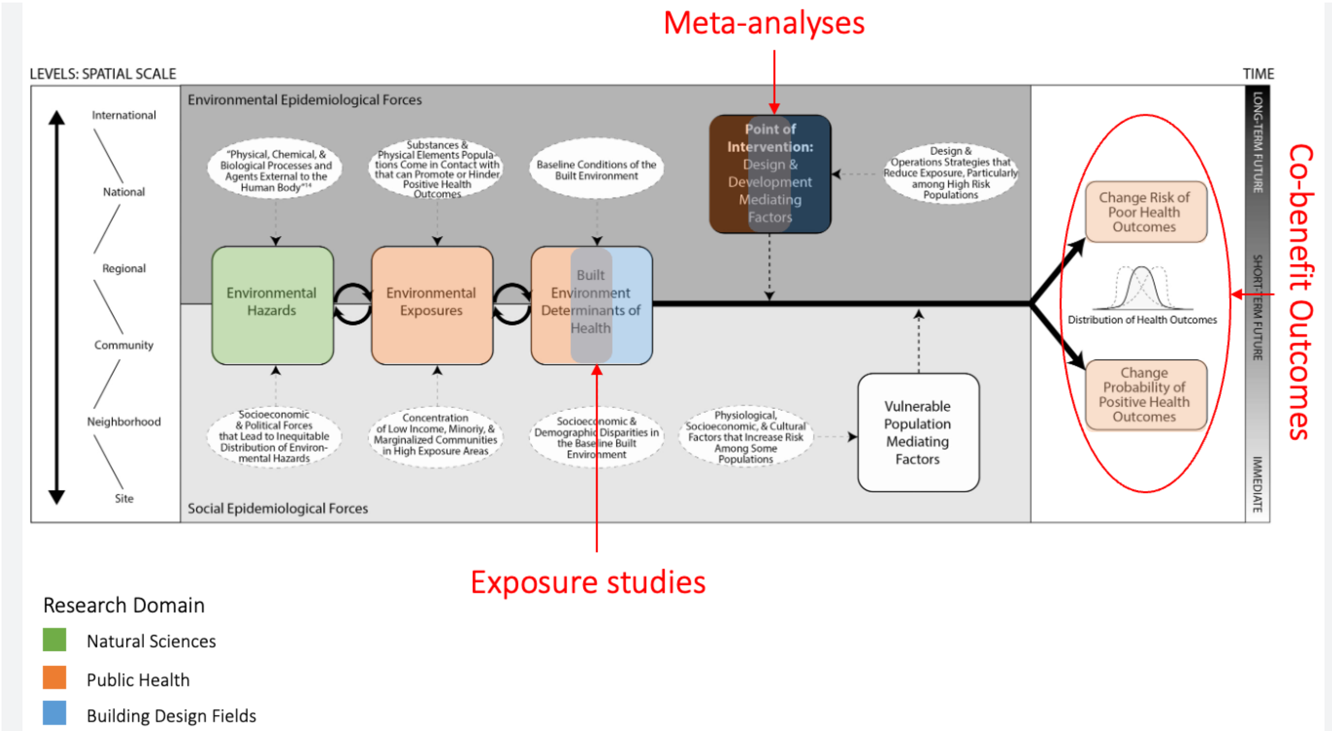


Figure 2. Architectural Epidemiology Conceptual Framework and Gaps in Research. Image credit. Houghton A, Castillo-Salgado C. Architectural Epidemiology: Introducing a Transdisciplinary Field of Study and Practice Using Real Estate as a Mechanism for Epidemiological Interventions on Climate Change and Chronic Disease. In: Jarrett C, Sharag-Eldin A, eds. Proceedings of the ARCC-EAAE 2022 International Conference, Resilient City: Physical, Social, and Economic Perspectives. Architectural Research Centers Consortium, Inc.; 2022:41-48. http://www.arcc-arch.org/wp-content/uploads/2022/09/Download-2022-Proceedings.pdf

A social epidemiologist would then ask whether there are socioeconomic and political forces at work in the neighborhood, community, or region where the project is located that have led to an inequitable distribution of environmental hazards. For example, a study in Phoenix, AZ, found that surface temperature and the human thermal comfort index varied across different neighborhoods over the course of the summer. Neighborhoods with low income and ethnic minority populations experienced higher temperatures and heat stress.[5]

Moving one box to the right, environmental exposure refers to the pathway(s) by which an individual or population is exposed to the environmental hazard in question. Continuing with the Phoenix example, an environmental epidemiologist might ask how the population comes in contact with high temperatures. How does the heat make its way through a building's thermal barrier? How does tree cover lead to differences in surface temperature across neighborhoods? The social epidemiologist would then ask whether there is a high concentration of marginalized or underserved populations in the neighborhoods with highest surface temperature and heat stress. If so, why? Are there behaviors related to socioeconomic circumstances, professions (such as construction worker, factory worker, or landscaper), and the distribution of resources like cooling centers that increase the risk of exposure in some groups above and beyond their baseline environmental exposure?

The next box, built environment determinants of health, is where environmental epidemiologists (working with design professionals) establish the baseline conditions of the built environment that contribute to or reduce disparities in environmental exposures. It is also where social epidemiologists and their partners map the overlap between socioeconomic and demographic disparities and current features of the built environment (such as tree canopy, white roofs, insulation, and shading) that protect some populations and other features (such as impervious surfaces, energy insecurity, and poorly maintained rental properties) that increase the risk of poor health outcomes in other neighborhoods when an extreme heat event takes place.

The black box, design and development mediating factors, is the focus of most architectural research about population health. It is also the part of the conceptual framework where the differences in the way the two fields – architecture and epidemiology – approach research is most evident.

## ARCHITECTURE AND EPIDEMIOLOGY: DIFFERENT APPROACHES TO RESEARCH

The current differences in the way the fields of architecture and epidemiology approach research on the links between the built environment and population health fall into three major categories: their research orientation, the way they craft research

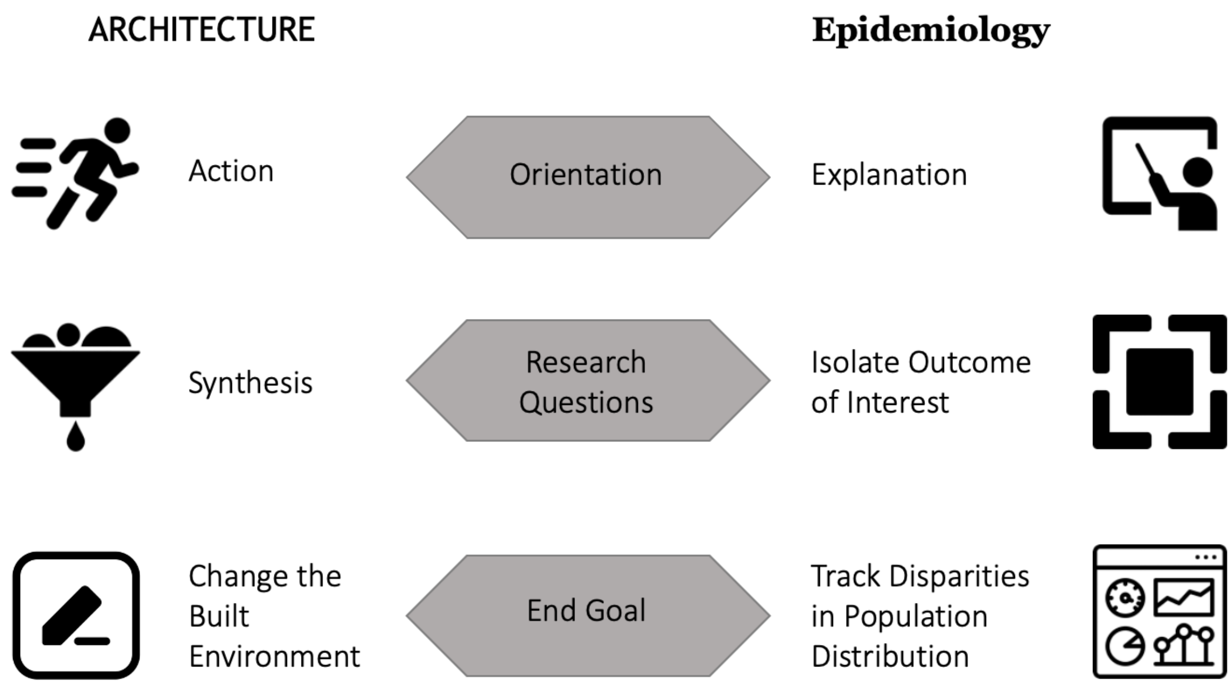


Figure 3. Comparison of Research Approaches: Architecture and Epidemiology

questions, and their end goal (Figure 3). We will consider each of these topics in turn.

Orientation

When architects conduct research on the links between the built environment and population health, their orientation tends towards action: What would happen to current conditions if the built and natural environment were manipulated in some way? This orientation is natural to the field; because, the purpose of architectural design is to change the built environment.

Epidemiological research, on the other hand, is oriented toward explaining where disparities in health conditions exist and why. Even participatory action research,[6] which orients the researcher towards co-creating the research question, data collection, and ultimate recommendations with the population that is the focus of the research question, often leads to more passive interventions – such as education and raising awareness about a public health challenge or building capacity in the subject population.

Research Questions

Because the field of architecture is oriented toward action (i.e., changing the built environment) and because all building design synthesizes many different priorities and questions into a single design, architectural research questions tend to focus on how to synthesize an optimal suite of strategies and approaches that respond to the specific context of an individual site.

Epidemiology, on the other hand, follows social science methods, including biostatistics, which try to isolate one outcome of interest and understand the contributing factors to that outcome. Epidemiological research questions related to the built environment seek to isolate the relationship between a specific building design or land use intervention and its influence on environmental exposure (environmental epidemiologists) or socioeconomic/demographic disparities in health outcomes (social epidemiologists).

End Goal

Following the orientation and research questions typical of architectural research tracking the links between the built environment and population health, its end goal is motivated by a desire to understand why a design intervention has or has not had an effect on the status quo – whether environmental or social. Architectural researchers might seek to answer questions like: Which design strategies worked in concert with each other? Which ones did not have the desired effect? How can we change design methods, building technologies, public policies, financing structures, and other tools of the trade to get closer to the outcomes that we want?

The end goal of most epidemiological research naturally follows the field's orientation towards explanation and crafting a

| **American Institute of Architects<br>Architectural Research Agenda: 2019-2020**[7] | **Core Competencies for Applied Epidemiologists in Governmental Public Health Agencies: Assessment and Analysis – Senior Scientist/Subject Matter Expert** [8] |
|---|---|
| Overarching Principles<br>• Clearly identified goals prior to starting the research<br>• Contributes new knowledge to architecture and allied fields (e.g., adding to or revising existing knowledge, extending research in other fields to architecture)<br>• Follows validated, credible, systematic, and repeatable methods. Research is designed to be scaled and/or generalized beyond the scope of a single study.<br>• Meets AIA standards of ethics<br><br>Impact Areas<br>• Community<br>• Health<br>• Environment<br>• Technology<br>• Firm/practice<br><br>Addresses one or more of the following scales of practice:<br>Occupant scale: Individual/human<br>• Human behavior<br>• Health and wellbeing<br>• Neuroscience<br><br>Building scale: Building type, performance, delivery<br>• Building performance<br>• Technology<br>• Materials<br>• Project delivery and processes<br><br>Societal scale: Economy, equity, environment<br>• Urbanism<br>• Resilience and sustainability<br>• Climate change<br>• Community | • Validate the identification that a public health problem exists and is relevant to a specific population<br>• Coordinate an epidemiological tracking program specific to the public health issue<br>• Design an investigation of acute and chronic conditions and other adverse population health outcomes associated with the public health issue<br>• Craft a study design that addresses ethical and legal questions related to data collection, dissemination of results, etc.<br>• Protect data privacy during and after data collection.<br>• Use epidemiological methods to evaluate the data<br>  ▪ Create an analysis plan<br>  ▪ Evaluate frequencies, descriptive statistics, sensitivity/specificity, prevalence/incidence, positive predictive value, attributable, fraction, etc., depending on the research question<br>  ▪ Adjust data based on age or other characteristics, if needed<br>  ▪ Interpret correlations and, if relevant, strengths of association. Consider the possibility of confounders and effect modifiers.<br>• Evaluate results, develop conclusions, and propose key findings based on the data analysis<br>• Design evidence-based interventions in response to the research findings<br>• Evaluate the success of interventions to address the original public health issue<br>  ▪ Develop measurable program goals and objectives linked to the original research question to test whether the intervention results in a positive outcome<br>  ▪ Develop logic models and theories of change to explain how and why the proposed intervention is expected to result in a positive outcome<br>  ▪ Evaluate progress towards the intervention's objectives and make changes in response to underperformance |

Table 2. Comparison of Core Competencies for Research in Architecture and Applied Epidemiology.

research question that isolates a single outcome of interest. As a result, its end goal is to identify and track disparities across the population.

To demonstrate how these different orientations result in different research methods, Table 2 compares the American Institute of Architects (AIA) 2019-2020 research agenda with the core competencies developed for applied epidemiologists by the U.S. Centers for Disease Control and Prevention and the Council on State and Territorial Epidemiologists. Applied epidemiologists often work for local and state health departments – rather than research institutions. Their work informs local public health tracking and is often used to help develop and evaluate the success of public health programs. As a result, applied epidemiologists fall closer on the spectrum of action research (and, therefore, closer to architectural research's orientation) than some other subdisciplines in the field.

While the overarching principles in the AIA research agenda align relatively closely with the core competencies for applied epidemiology, they remain at a high level and do not provide detailed guidance on methods. The core competencies for applied epidemiologists, on the other hand, walk through methods step by step. Table 2 only displays the most general level of guidance in the applied epidemiology core competencies report. Each bullet point in the table is followed by multiple subsections with specific, step by step instructions.

It is also clear from comparing the impact areas and scales of practice in the AIA research agenda that architectural researchers develop research questions that synthesize information into an output that could be used to inform design decisions (which are, by definition, a distillation of multiple inputs – some of which conflict with each other). The AIA report goes into more detail about how the research can be applied to create change in the built environment at the occupant, building, and/or societal scale.

The core competencies for applied epidemiologists, on the other hand, start by isolating a single public health problem, validating its existence, and linking it with a specific population. All of the subsequent guidance builds off of that key point: the idea that the goal of research is to isolate an outcome of interest and better understand how it contributes to disparities in health outcomes among different populations within the jurisdiction of the public health department.

## ARCHITECTURAL EPIDEMIOLOGY: A JOINT RESEARCH AGENDA FOR THE FUTURE

Returning to the architectural epidemiology conceptual framework (Figure 2), the natural sciences (green highlight) have made great strides over the past few decades in explaining the natural processes underlying environmental hazards. And, public health research (orange highlight) has grown the body of knowledge on pathways of exposure. While many studies on the environmental hazards and exposure pathways related to climate change and health started at the global level, both sets of estimates are increasingly available at the community and even neighborhood (i.e., census tract) level, which is the scale that is most useful for informing building design decisions.

Public health studies like the heat study in Phoenix cited above have begun to isolate specific built environment determinants of health that could contribute to a reduction in poor health outcomes and/or increase the probability of positive health outcomes if implemented in the right location and among a population that would benefit from the intervention. Meanwhile, architectural studies have tested a variety of design strategies for their health benefits to building occupants. The Center for Health Design[9] is a leader in this space, focusing on using design interventions to improve patient health outcomes. Green and healthy building best practice guides like Fitwel[10] and WELL[11] have compiled narrative literature reviews on the state of the science linking building design and land use configuration to certain health outcomes.

The architectural epidemiology conceptual framework suggests a collaborative research agenda that would build on the strengths of both fields, particularly in three areas: exposure studies, meta-analyses, and research on outcomes with co-benefits.

### Exposure Studies

The majority of the public health research on the built environment determinants of health has attempted to isolate how environmental hazards move through the built environment, expose a population to a harmful substance or situation, and ultimately increase the risk of certain health outcomes. However, isolating an exposure pathway is not the same thing as proving that an action – i.e., a design intervention – led to a more positive outcome than if that intervention had not been put in place. The author has used the exposure studies available on the links between the built environment and exposure to extreme heat[12] and flooding[13] to develop lists of evidence-based design strategies targeting these two events. However, because the overwhelming majority of the studies included in the systematic literature reviews on these topics were explanatory rather than action-focused, her results are limited to listing a set of evidence-based strategies without including a taxonomy explaining which design strategy would be more protective in certain environmental or social contexts. A research agenda for architectural epidemiology would take that next step moving from explanatory exposure studies to studies that test out the relative benefits of different design strategies in a variety of contexts.

### Meta-analysis

The second feature of a research agenda for architectural epidemiology would bring a more systematic approach to designing research about the built environment. Currently, exposure studies linking the built environment determinants of health with population exposure and/or health outcomes use such a wide range of methods that it is not possible to combine the results into a meta-analysis, which would allow researchers to begin to estimate the relative benefit of one set of strategies versus another in a specific location with a specific population.

Co-benefit Research

Finally, and most importantly, architectural research's bias towards asking research questions that synthesize multiple strands of enquiry into a coherent design concept could be folded into a research agenda for architectural epidemiology by emphasizing the value of quantifying the co-benefits and co-harms that are estimated to result from a single or set of design interventions.[14] For example, rather than designing a study to isolate a design's effect on exposure to traffic related air pollution, a study designed along the lines of the architectural epidemiology conceptual framework would instead consider how the design could also actively reduce on-site and off-site sources of air pollution; mitigate the urban heat island; mitigate flood risk; produce on-site renewable energy (which both reduces exposure to on-site sources of combustion and could be designed to power the air conditioning when the power goes out); and, protect occupants and the surrounding neighborhood from exposure to heat, flooding, mold growth, and disease-carrying vectors like mosquitoes.

## CONCLUSION

This paper used the conceptual model for a proposed new, transdisciplinary subfield called architectural epidemiology to map out how current public health and architectural research complement each other. It also identified research gaps in both fields and proposed a transdisciplinary research agenda based on the architectural epidemiology conceptual framework.

## ENDNOTES


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