Journal of Infrastructure, Policy and Development 2025, 9(3), 11732.
https://doi.org/10.24294/jipd11732

Article

Architectural responses to public health transitions: Evolving concepts & tech

Jia Li Li[1], **Tong Cui**[1,2,*]

[1] School of Sciences for the Habitat, University of Chinese Academy of Sciences, Beijing 100190, China
[2] China Construction Engineering Design & Research Institute Co., Ltd., Beijing 100037, China
*** Corresponding author:** Tong Cui, cuitong@ucas.ac.cn

CITATION

Li JL, Cui T. (2025). Architectural responses to public health transitions: Evolving concepts & tech. Journal of Infrastructure, Policy and Development. 9(3): 11732. https://doi.org/10.24294/jipd11732

ARTICLE INFO

Received: 3 May 2025
Revised: 14 July 2025
Accepted: 16 July 2025
Available online: 31 July 2025

Abstract: In the history of public health, space has evolved through several stages driven by shifts in concepts of disease control. The history of public health is summarized by George Rosen in six phases: Origins (before 500 CE), Middle Ages (500–1500), Mercantilism and Absolutism (1500–1750), Enlightenment and Revolution (1750–1830), Industrialism and the Sanitary Movement (1830–1875), and the Bacteriological Era (1875–present). By integrating architectural sociology—a temporal lens examining the interplay between architecture, individuals, and society—this study investigates how architects historically responded to public health challenges, offering critical insights for contemporary healthy habitat design. Architecture not only addresses survival needs but also materializes societal consciousness. The progression of health-related cognition (e.g., germ theory), behavioural norms (e.g., hygiene practices), infrastructure systems (e.g., sanitation networks), and scientific advancements collectively redefined spatial paradigms. Architects constructed temples, thermae, lazarettos, Beitian Yangbingfang (charitable infirmaries), anatomical theaters, quarantine hospitals, tenements, mass housing, and biosafety laboratories. These cases exemplify the co-evolution of "Concept" (disease control ideologies), "Technology" (construction methods), and "Space" (built environments). By synthesizing centuries of public health spatial practices, this research deciphers the dynamic interplay among "Concept, Technology, and Space". Leveraging historical patterns, we propose a predictive framework to refine future spatial strategies in anticipation of emerging health crises.

Keywords: public health; space sociology; bio-security; healthy building

1. Introduction

In the 1980s, Chinese scholars synthesized the core issues of architecture into five key aspects: "relationship with science and technology," "relationship with social systems (including religion)," "relationship with social consciousness," "relationship with social issues," and "socialized production of architecture" (Dou, 1987). Louis Kahn posited that the eternal Order (essence of architecture) is perceived through human cognition and customs, which in turn generate new forms and functions (Tyng, 1984). Contemporary academic consensus maintains that space effectively guides human behavioral patterns. The tripartite interaction between cognition, behavior, and space requires diachronic analysis spanning past and present contexts, while projecting future trajectories (Tang, 2022; Ou et al., 2023).

Public health, as an interdisciplinary intersection of sociology and architecture in distinct historical turning points, provides exemplary models for studying how space responds to social issues. The concept of public health has evolved over time and was defined in 1920 as "the science and art of preventing disease, prolonging life, and promoting health through organized community efforts" (Winslow, 1920).

Historically, public health efforts encompassed sanitation improvements, epidemic prevention, health behavior guidance, healthcare service organization, and health standard regulation. Though closely related to medicine, public health maintains fundamentally closer alignment with social science disciplines in practice (Guo et al., 2024).

This study investigates the long history of humanity's struggle against epidemics, focusing on critical spatial responses to health challenges (**Figure 1**). With anthropological and sociological methods, we construct a "Concept-Technology-Space" theoretical framework to analyze how ideas about health, technical implementations and spatial manifestations have evolved in relation to one another.

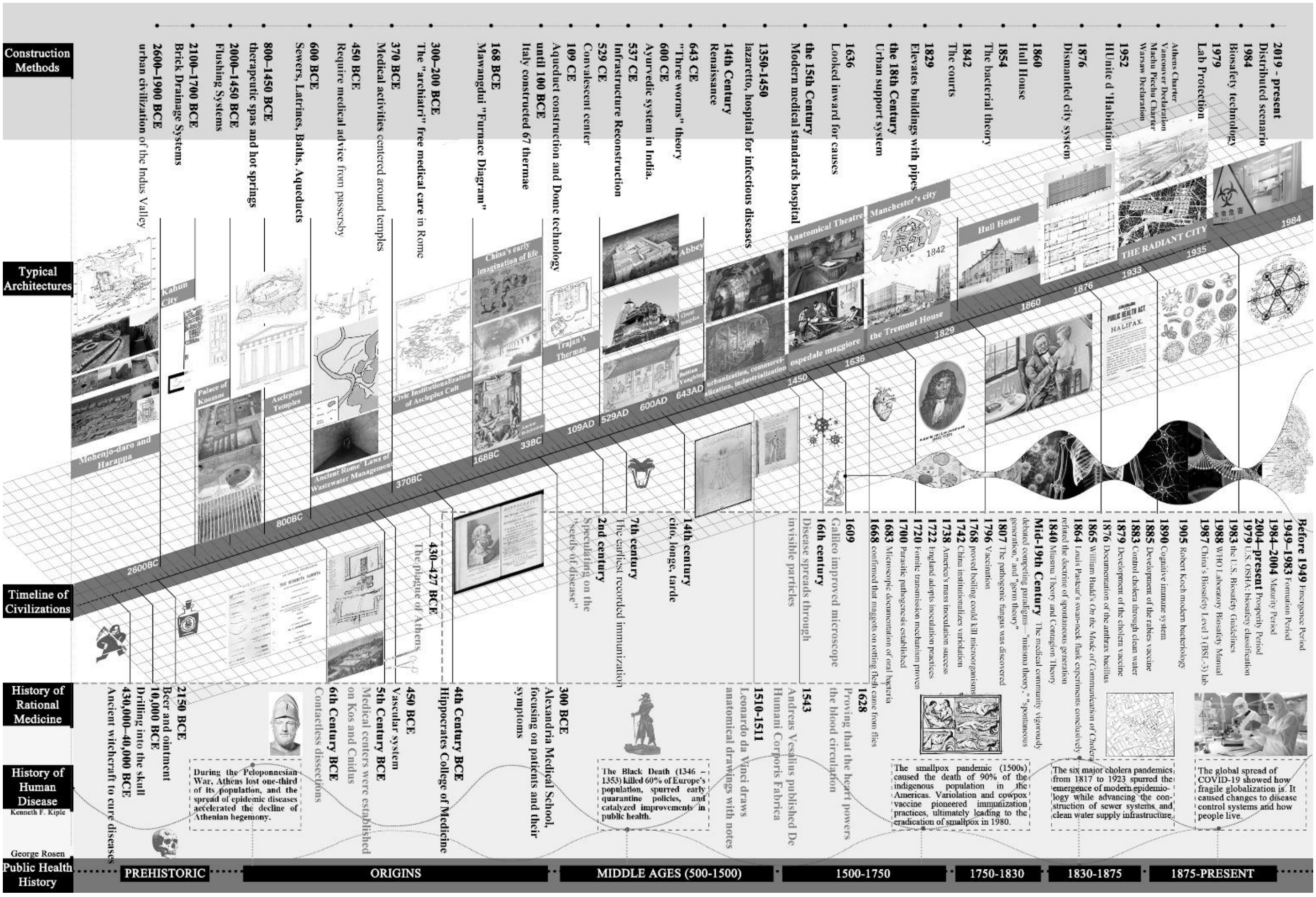

Figure 1. Typical spatial analysis in public health history.

Source: Original work by the author integrating multidisciplinary sources, 2025. Historical data extracted from: Kenneth (1993), Robert (2020), Rosen (1958). Visual references include: Wikimedia Commons, Wellcome Collection.

2. Materials and methods

Architects have long played a key role in preventing disease through thoughtful material choices and spatial strategies. Classic architectural treatises and movements consistently engage with public health concerns.

In *De Architectura* (1st century BCE), Vitruvius (1914) prescribed health-conscious spatial solutions, asserting that "architects must understand medicine." He also advised siting healing temples on elevated terrain away from marshes, incorporating fresh springs, optimizing daylight exposure, designing open-air exercise grounds, deploying saline water for disinfection, and implementing effective drainage systems. Hippocrates (1526) systematically analyzed spatial determinants of disease in *Airs, Waters and Places*. In Eastern traditions, Guo Pu articulated environmental health principles through feng shui theory. Qi disperses with wind and accumulates near water. Ancient wisdom balanced the nurturing and destructive forces of wind and water through strategic site selection. Chinese architectural classics like *Kao Gong Ji* and *Ying Zao Fa Shi* documented technical solutions for epidemic prevention, including ventilation optimization, sewage drainage system, and moisture-proof lime mortars.

Benjamin Ward Richardson's *Hygeia: A City of Health* (1876) systematically outlined how diverse spaces can promote healthy behaviors through thoughtful design (Richardson, 1876). Similarly, Jane Jacobs' *the Death and Life of Great American Cities* and Ebenezer Howard's *Garden Cities of To-morrow* also discussed the concept of urban functional zoning. By the late 19th century, recurring plagues in Europe pushed CIAM to integrate sanitary infrastructure into modernist planning, recognizing disease prevention as fundamental to urban progress. After World War II, a passive urban health system centered on disease prevention and treatment facilities proliferated globally, with a layered system of hierarchical hospitals and rehabilitation infrastructure emerging at different urban scales. In the early 20th century, architects curbed the spread of epidemics in New York through active health interventions, such as layout optimization, airflow management, segregation of clean and contaminated zones and density reduction. International conferences and declarations from this period also emphasized the importance of healthy human settlements (**Table 1**). The advancement of bacteriology led to the invention of laboratory biosafety cabinets (1943), which have provided technical insights into modular system design and precision management protocols for health-focused building design. Constant published *For a Situational Architecture* (1953) proposes a new urban theory that architectural practice could transform everyday behaviors and ideologies. The Situationist International (1957–1972) advanced the theory of psychogeography, employing artistic and technological means to construct spatial environments that would actively shape the behaviors of their inhabitants. Raoul Vaneigem's *the Revolution of Everyday Life* (1967) critiqued the alienation caused by industrialized space (Debord, 1994; Park, 1925; Vaneigem, 1983).

Table 1. International declarations emphasizing healthy human settlements.

Ideology	Time	Viewpoints
Athens Charter	1933	Human-centered planning of urban functions
Vancouver Declaration on Human Settments	1976	Concern for the improvement of settlement and environmental problems in backward areas
MACHU PICCHU Charter	1977	Emphasis on rational interaction between human and nature
Warsaw Declaration	1981	Satisfy people's high quality needs in terms of health, safety and comfort

Source: The author compiled this based on public data.

Risk Assessment in the Federal Government: Managing the Process (1983) from the U.S. National Academy of Sciences established a framework for public engagement and systematic evaluation of health impacts in policy decision-making (**Figure 2**) (Xu et al., 2018). The Ottawa Charter (1986) on Health Promotion defined five action areas: developing healthy public policies, creating supportive environments, strengthening community action, developing personal skills, and reorienting health services. It emphasized resource allocation efficiency and integrated healthcare into occupational and living environments. Sweden hosted two international academic conferences about "Healthy Buildings" in 1987 and 1988, evaluating how architecture contributes to human health directly (Wang et al., 2018). In 1989, the World Health Organization (WHO) expanded its health definition to encompass physical, mental, social, and moral well-being. Since 1990, health-focused building evaluation systems have diversified significantly. Notable examples include the WHO's "15 Principles for Healthy Housing," Canada's "Super E" certification, the expansion of the UK's BREEAM system to address holistic performance, Delos' WELL Building Standard integrating physiological metrics, the CDC-GSA collaborative Fitwel rating system, and Harvard University's *The 9 Foundations of a Healthy Building* which integrate research spanning environmental psychology, ergonomics and daily productivity optimization.

Figure 2. Environmental decision-making management framework diagram (Xu et al., 2018).

A systematic review of disciplinary literature from the past decade (**Figure 3**) reveals distinct research trajectories. Before 2014, scholars predominantly addressed building energy efficiency, safety and air quality. Professor Zhang (2016) suggests that spatial design can actively foster health-promoting behaviors by intervening experiential engagement, social connectivity, ergonomic optimization, and playful interaction (Zhang, 2016). After 2018, the research pivoted toward functional configurations, systems and evaluative metric development. In 2020, the volume of literature on health-related topics surged rapidly, characterized by interdisciplinary integration and advanced optimization of data granularity. Current research focuses on adaptive design, epidemic-normalization integration, health promotion and community resilience.

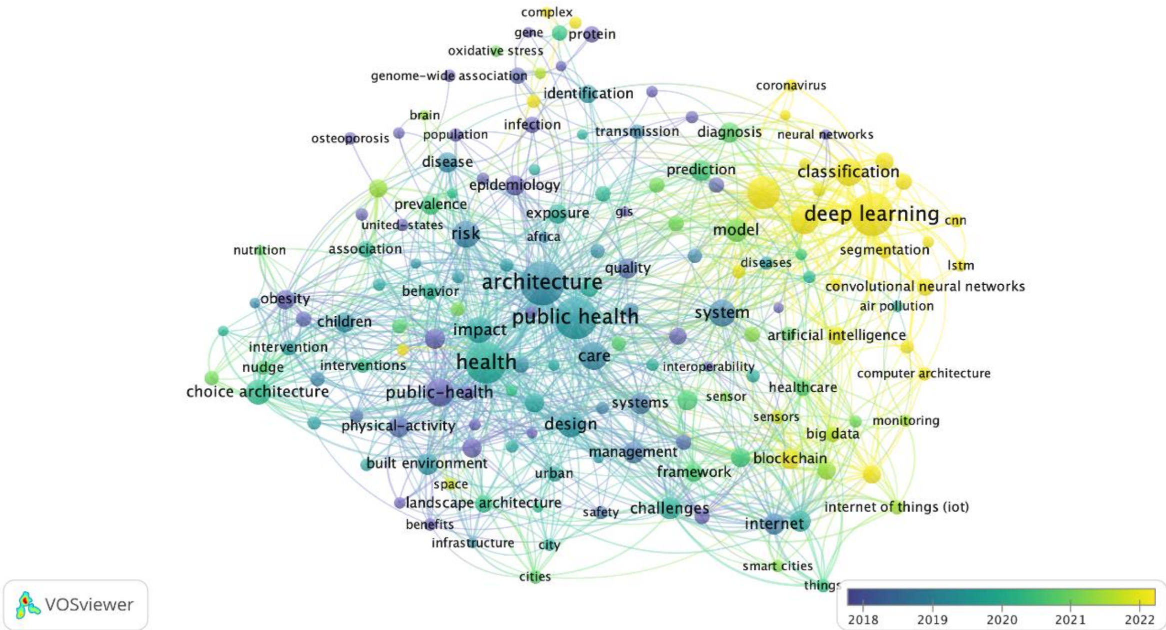

Figure 3. Public health-architecture keyword co-occurrence network diagram.

Source: Author.

2.1. Interdisciplinary methodology

Understanding the relationship between health and space requires more than architectural and medical expertise —it demands anthropological and sociological perspectives. Lineage branches across Eurasia, East Asia, Southern Africa and the Americas have evolved distinct perceptions of disease, such as the Hippocratic doctrine, the *Sanshi* (Three Worms) theory and Ayurveda—over millennia of civilizational development, shaping both epidemic responses and spatial forms. Following George Rosen's *A History of Public Health*, this study traces the six established historical phases of public health to identify representative spatial typologies that responded to health crises at pivotal junctures. There are Origins (before 500 CE), Middle Ages (500–1500), Mercantilism and Absolutism (1500–1750), Enlightenment and Revolution (1750–1830), Industrialism and the Sanitary Movement (1830–1875), and the Bacteriological Era (1875–present) (Rosen, 1958). As society's understanding of disease origins and its transmission evolved alongside protective technologies, Rosen notes that societies constructed various spaces, such as temples, thermae, lazarettos, Beitian Yangbingfang, anatomical theaters, quarantine hospitals, tenements, mass housing and biosafety laboratories, to address health challenges. By conducting a diachronic and multi-case comparison in an architectural macro-perspective, this paper synthesizes these pivotal spaces that transformed disease control and analyzes their emergence, evolution and trends in aspects of natural interaction, system decoupling, isolation technologies and behavioral guidance.

2.2. Root cause analytical framework

Spatial Sociology focuses on the underlying causes of the production and transformation of spatial structures. In *The Production of Space,* Henri Lefebvre (1974) posits, "What we concerned is not to contemplate space in the abstract, but to decode the contradictions within it and resolve them through transformed practice—or, better still, to propose a space capable of resolving such contradictions". Michel Foucault (1961), in *Madness and Civilization: A History of Insanity in the Age of Reason*, began his analysis with leprosy and note that the Nancy Leper House, one of Europe's largest leprosariums, accommodated only four patients during the Medici Regency, a spatial representation of power and politics in that era. Charles Booth's seminal work in human ecology, *Life and Labour of the People in London* (1886), examines the spatial conditions of workers across different occupations. Friedrich Engels (1887), in his *The Condition of the Working Class in England in* 1844, highlights how the spread of infectious diseases eroded the survival disparities between slums and affluent districts, compelling capitalists to improve urban spaces (Cheng, 2023). This study, grounded in the understanding of the complex and multifaceted factors inherent in public health crises, seeks to clarify the dynamic interplay among "Concept, Technology and Space."

3. Results and discussion

As mentioned in Section 2 (Materials and methods), this paper spans diverse disciplines including public health, medicine and history. Based on the frameworks in *A History of Public Health* by George Rosen (1958) and *The Cambridge World History of Human Disease* by Kenneth F. Kiple (1993), this research examined evolving concepts and technologies across historical era, particularly in medicine and construction. With the background in architecture, the author investigated the traces of spatial responses to health issues and returned to architectural history to correlate contemporaneous practices and ideologies. For instance, empirical observations manifested that frequent bathing reduced disease incidence. As aqueduct engineering and dome construction technologies matured, these advances were established spatially through complex, multistage bathing complexes.

A key concept in spatial sociology is that space is designed to address contemporary problems. However, when addressing the same issue, "disease", space has manifested in different forms across distinct historical periods. The underlying reasons are tied to the respective conceptions and technologies of different eras. This research employs Material Culture Analysis and Root Cause Analysis to investigate public health history for traces of spatial responses to health issues. This study attempts to systematize the evolutionary trajectory of architectural responses to public health and delineate period-specific spatial response modes organized chronologically in subsequent sections.

3.1. Pre-1500 spatial paradigms—Emulating nature with comprehensive functional elements

During the scatter-settlement phase, disease transmission exhibited stochastic patterns with unpredictable emergence and remission. Philosophers of this era sought causes of illness through empirical induction, giving rise to diverse etiological frameworks across civilizations: humoral theory (Greece/Rome), qi circulation (China), divine oracles (Mesopotamia) and cosmic retribution (India) (Kiple, 1993). During this period, xenodochia (nosocomia) evolved into multifunctional spaces for health care. Religious institutions, such as Monte Cassino Abbey (Italy) and the Abbey of Saint Gall (Switzerland), were repurposed for charitable relief and medical convalescence (Rosen, 1958). In China, the Mawangdui silk manuscripts depict the world as a cosmic furnace for smelting metal. Within this cosmology, Disease represented a state of internal disorder, treated through acupuncture and diet (Lü, 2022). Meanwhile, grand Indian temples serving as the primary venue for the transmission, study and practice of Ayurvedic theory (Rosen, 1958). The healing spaces of this period—temples, thermae, Beitian Yangbingfang, and others—were all characterized by their imitation of natural environments and comprehensive facilities, reflecting both a reverence for nature and a disciplined structuring of daily living habits (**Figure 4**).

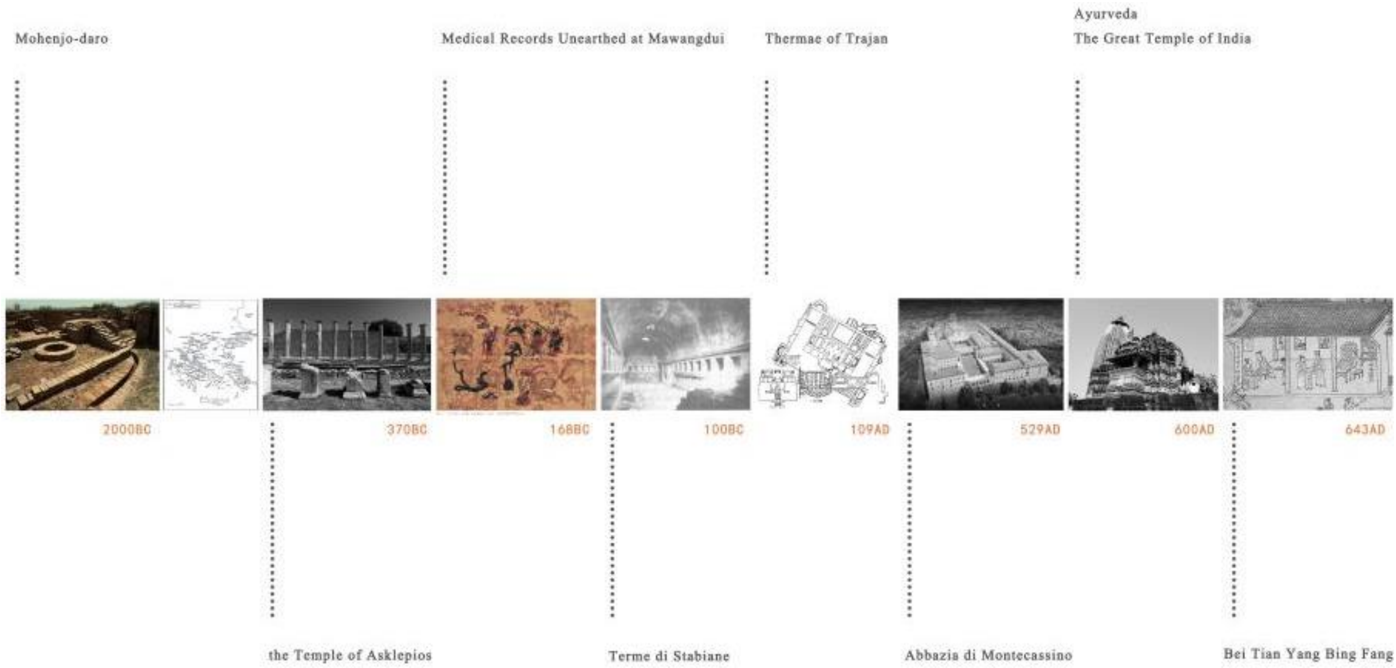

Figure 4. Spatial exploration before 1500.

Source: Original work by the author integrating multidisciplinary sources, 2025. Historical data extracted from: Kenneth (1993), Robert (2020), Rosen (1958). Visual references include: Wikimedia Commons, Wellcome Collection.

In *Airs, Waters, and Places*, Hippocrates (1526) proposed the use of regimen to address the Athenian plague during the Peloponnesian War (430–426 BCE), he emphasized the harmony between the human body and natural rhythms (**Figure 5**). During this period, medical activities were long centered around the Temple of Asclepius, leading to the construction of numerous temples. Following Hippocrates' guidelines, these temples were built near the sea, with fresh air and clean water sources, accommodating needs for bathing, fasting and ointment therapies. They were also equipped with theaters, gymnasiums and hippodromes to provide physical and spiritual therapy for chronic patients (**Figure 6**). Patients' beds were placed beneath divine statues, exposed to healing through divine intervention in sleep. Newly arranged sickbeds meticulously emulated precedents of successful cures, replicating spatial configurations in hopes of repeating therapeutic outcomes (Hao, 2017).

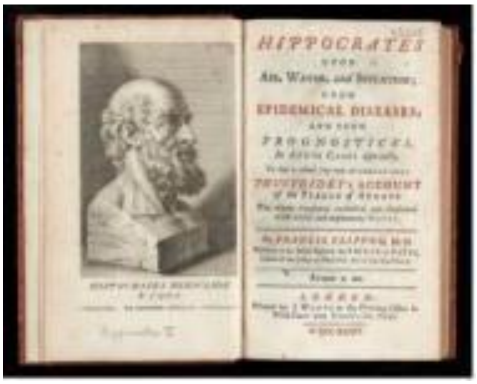

Figure 5. Title page of Hippocrates' airs, waters, and places (WIKIMEDIA COMMONS, 2018).

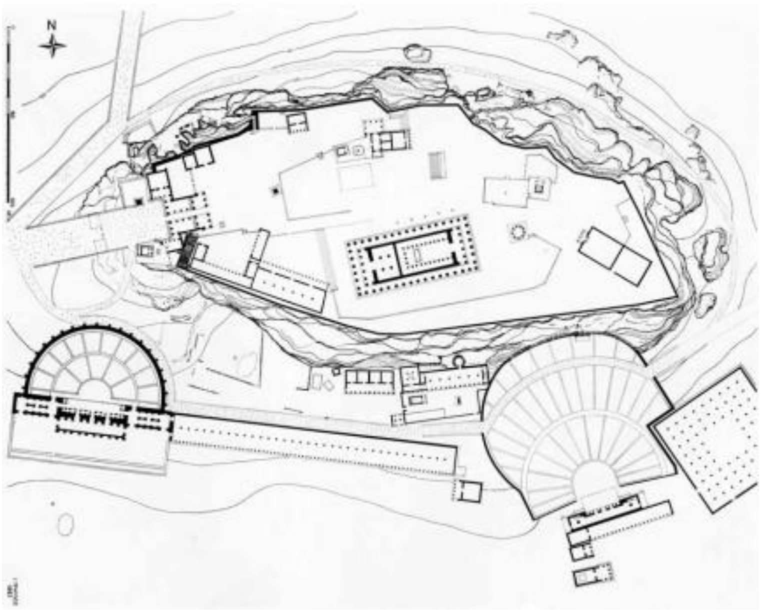

Figure 6. Asclepeion temple complex (Hao, 2017).

By 100 BCE, approximately 67 thermae had been constructed in Italy, primarily concentrated in Rome, Ostia and Pompeii. *De Architectura* underscores bathing as a necessity for sustaining health, reflecting the exploration of healthy living practices in this era. The construction of thermae complexes addressed health requirements through spatial considerations, including warm wind-sheltered site selection, efficiently arranged furnaces, uniformly converging water channels and strictly calculated height-to-width ratios (**Figure 7**) (Vitruvius, 1914). With advancements in aqueduct and vaulted roof technologies, the interior scale of thermae expanded significantly, gradually incorporating additional amenities, such as swimming pools and athletic grounds. Trajan's Thermae (109 CE), designed by Apollodorus of Damascus, exemplifies axial symmetry through its rectangular plan. The primary bathing sequence—caldarium, tepidarium and frigidarium—occupies the central axis, while ancillary spaces (apodyteria, unctuaria, sudatoria) flank symmetrically.

Subterranean service zones (boiler rooms, storage areas and servile accommodations) were distinctly separated from exercise/bathing circulations, achieving clear functional zoning (**Figure 8**) (Guan, 2017).

Figure 7. Stabian thermae in Pompeii (Vitruvius, 1914).

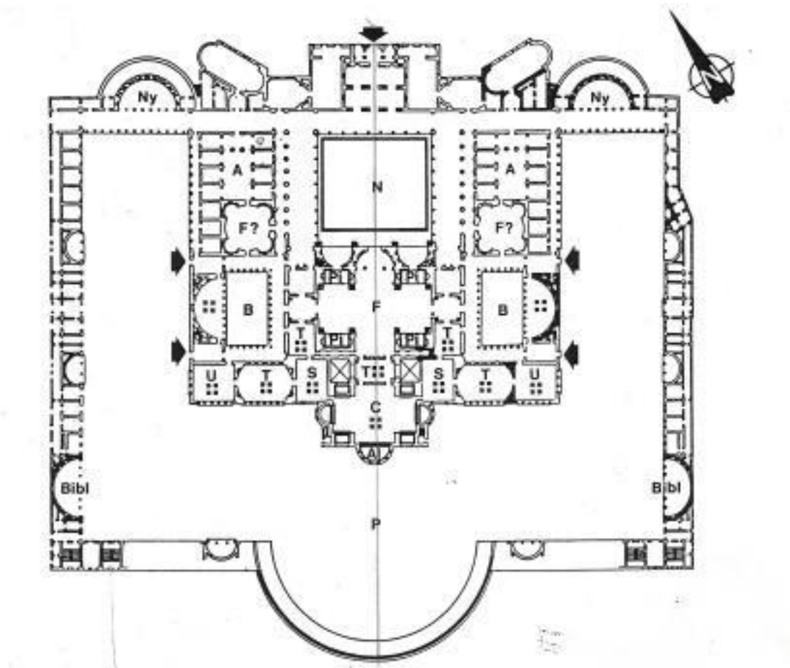

Figure 8. Floor plan of Trajan's thermae (Guan, 2017).

Figure 9. The "Deities diagram" from Mawangdui (Lü, 2022).

During Emperor Xuanzong's reign of the Tang Dynasty (846–859 CE), the Beitian Yangbingfang for the poor and sick were established nationwide. Their prosperity was closely related to the development of the "Three Worms Theory" during the Han and Tang dynasties (Qi, 2006). Based on the "Furnace Diagram" silk painting (**Figure 9**) from the Mawangdui Han Tomb, the "Three Worms Theory" visually conceptualized the invasion of parasites and poisonous insects (Lü, 2022).

According to historical records and mural depictions, the layout of the Beitian Yangbingfang included the following functional areas (**Figure 10**): monastic quarters, fruit orchards, bathing pools, gardens, medical facilities, infrastructure, wells and hygienic latrines. The integration of healthcare functions with daily psychological and physiological needs demonstrates striking parallels with Asclepeion Temple Complex mentioned previously.

Figure 10. Depiction of the Beitian Yangbingfang in the murals of Mogao Caves, Dunhuang (Bai, 2021).

3.2. Spatial paradigms of 1501–1875—Reconfiguration of order and functional differentiation

Italy pioneered the "cito, longe, tarde" spatial isolation strategy. However, maritime trade expansion paradoxically amplified epidemics and mortality through mass mobility. Ragusa institutionalized the 30-day quarantine, confining contacts of the infected in lazzaretto, the proto-infectious disease hospital (Rosen, 1958). The Renaissance catalyzed a civilizational shift toward human-centric political-economic orders, exemplified by public health committees wielding surveillance, isolation, confiscation and disposal powers. Rulers and religious authorities co-opted medical provision for power consolidation, with the Ospedale Maggiore in Milan emerging as the first hospital transcending medieval "almshouse" models through rationally organized medical systems. The government spearheaded the standardized construction of sanitary facilities, such as bathhouses, sewers and public latrines. Anatomical studies redirected medical gaze inward to pathological bodies, while modern medicine, immunology and nutrition began taking shape (Kiple, 1993). *An Essay Concerning Human Understanding*'s exploration of environmental influences facilitated the integration of milk stations, maternal-child health centers and neighborhood clinics into daily life (Locke, 1975).

In summary, this period's spatial reforms focused on systematic rational deconstruction (**Figure 11**).

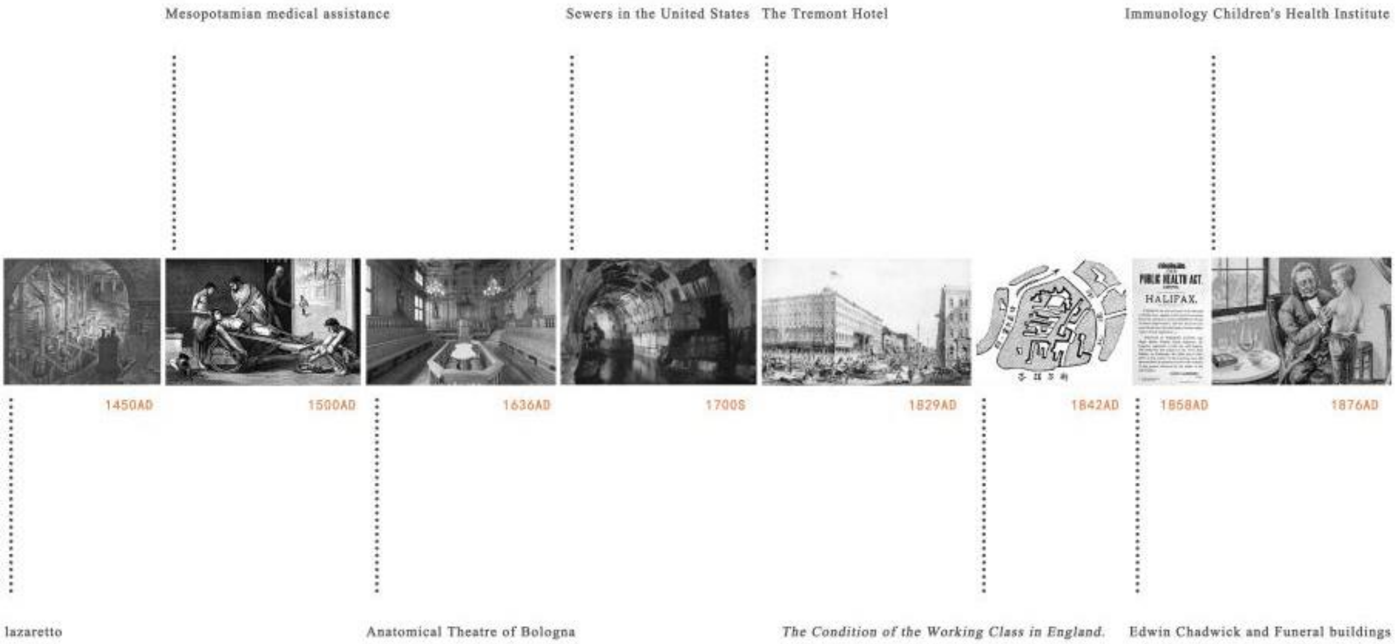

Figure 11. Spatial exploration during 1501–1875.

Source: Original work by the author integrating multidisciplinary sources, 2025. Historical data extracted from: Kenneth (1993), Robert (2020), Rosen (1958). Visual references include: Wikimedia Commons, Wellcome Collection.

In 16th–17th century Europe, the emergence of anatomical classrooms transformed human dissection from a public spectacle of morbid curiosity into a formalized component of medical education. Distinct from the chaotic "anatomical theaters" open to public, Bologna's Archiginnasio Anatomical Theatre (1563) was recognized as the world's first dedicated human anatomy laboratory (**Figures 12–14**). Constructed entirely of fir wood, the space centered around a marble dissection table. Its design balanced operational demonstration and scholarly discussion. At the time when bacteria remained undiscovered, the laboratory incorporated spatial elements, such as blood drainage grooves on the table, tall windows for ample lighting and optimized ventilation—features inspired by the human circulatory system. These innovations laid the groundwork for the systematic separation of laboratory functions.

Figure 12. Bologna's Archiginnasio anatomical theatre (Gao, 2019).

Figure 13. Anatomical theatre at the University of Padua (Gao, 2019).

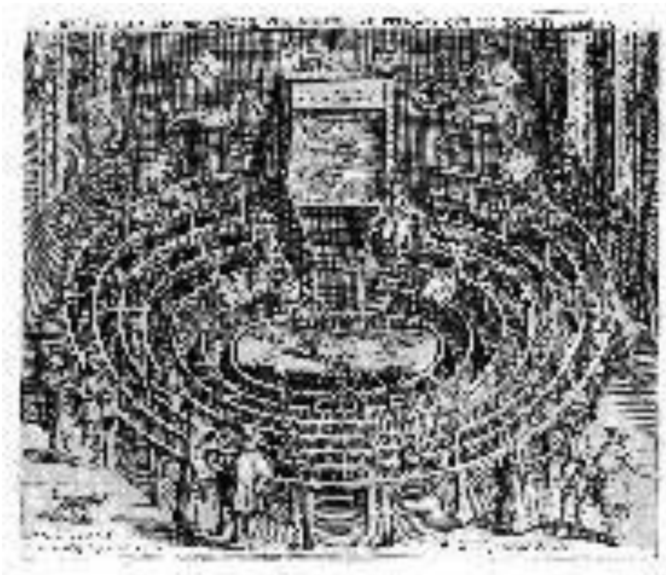

Figure 14. Anatomical theatre at Leiden University (Gao, 2019).

Figure 15. The Tremont House (James, 1866).

In 1854, John Snow mapped cholera cases in London's Soho district, tracing the outbreak to fecal-contaminated water sources. Around the same period, Chicago began constructing its sewer system. To lay underground pipes, streets and downtown buildings required elevation. In 1861, architect George Pullman achieved a groundbreaking feat by raising the Tremont House (built in 1829) using load-bearing timbers and screw jacks (**Figures 15** and **16**). With brick and stone foundations beneath the structure and underground sewer lines, the Tremont House pioneered the integration of private bathrooms in luxury hotels. Over the following half-century, private bathrooms gradually became a standard feature in individual guest rooms.

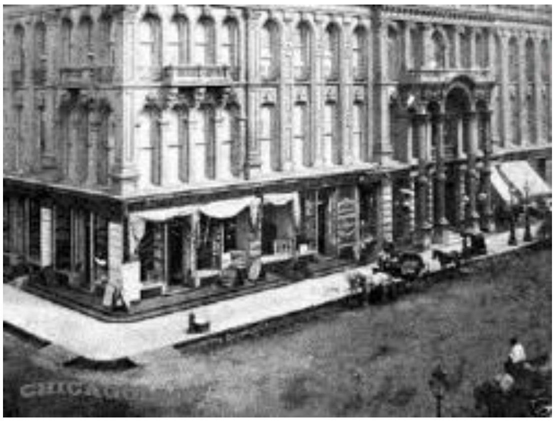

Figure 16. Building elevated to street level (Chicagology, 2021).

Friedrich Engels' seminal work *The Condition of the Working Class in England* documents observations during his residence in Britain (1842–1844), noting that courts became the most common proletarian housing in Manchester, Lancashire, Yorkshire and other regions. The text describes how these courts were distributed in a completely unplanned manner, resulting in stagnant air circulation. The ground floors, situated below road level, caused water to accumulate across the surfaces during rainy periods. These courts were linked by covered back-streets, with entry gates opening onto the alleys and sharing a rear wall with adjacent courts (**Figures 17** and **18**). All these conditions proved severely detrimental to the health of the inhabitants (Engels, 1887).

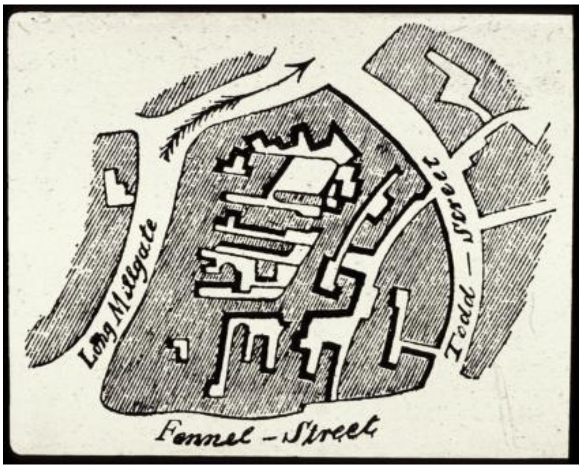

Figure 17. Section of Manchester's city plan (Engels, 1887).

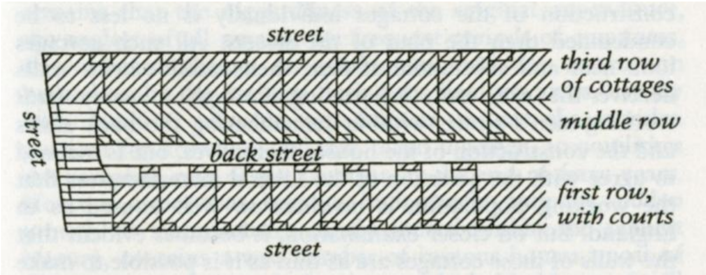

Figure 18. Courts layout (Engels, 1887).

The repeated ravages of epidemics, such as cholera, typhus and smallpox, compelled the British bourgeoisie to recognize that improving sanitary conditions in urban slums was imperative if they wished to spare themselves and their families from victims of contagion. Pioneers in public health firmly believed that environmental engineering held the key to addressing disease and health risks. Edwin Chadwick, regarded as the father of British public health, formally published *The Sanitary Condition of the Labouring Population of Great Britain* in 1842, while Lemuel Shattuck, a trailblazer in American public health reform, produced *Report of a General Plan for the Promotion of Public and Personal Health* in 1850. Both works urged architects and urban planners to prioritize the living conditions of the impoverished. In the memoir *Reminiscences of an Octogenarian of the City of New York* (1816 to 1860) by Charles Haynes Haswell, it is noted that employers began constructing low-cost tenements for workers to meet basic housing needs around 1833, though these dwellings remained overcrowded with substandard sanitation and inadequate water supply.

3.3. Spatial paradigms from 1875-present: Systematic decomposition & circulation organization via scientific methodology

In the 17th century, Antonie van Leeuwenhoek observed microorganisms through his self-made microscope. By 1876, Robert Koch had become the first to demonstrate that bacteria could cause diseases. By the late 19th century, it had been identified that the pathogens is responsible for most infectious diseases. With the rising of understanding that the target of disease prevention lay in pathogenic microorganisms, bacteriology and immunology advanced rapidly. This knowledge enabled more precise deconstruction of spatial functions and circulation patterns (**Figure 19**), dividing scenarios into two categories: routine guidance (e.g., urban planning concepts like the Garden City, Radiant City and Broadacre City, which aimed to reconcile urban density with healthy living through spatial design) and targeted control (e.g., flow-line optimization and protective technologies for biosafety laboratory). These approaches reflect the evolving, multidimensional concept of "health" in modern discourse.

In 1876, Benjamin Ward Richardson (1876) authored *Hygeia, a City of Health*, aiming to enhance residents' physical and mental well-being by systematically deconstructing the ideal healthy city. His work outlined comprehensive systems of urban, including residential areas, streets, parks, hospitals, public facilities and supporting elements, such as proper ventilation, sufficient daylight, clean water supply and waste segregation.

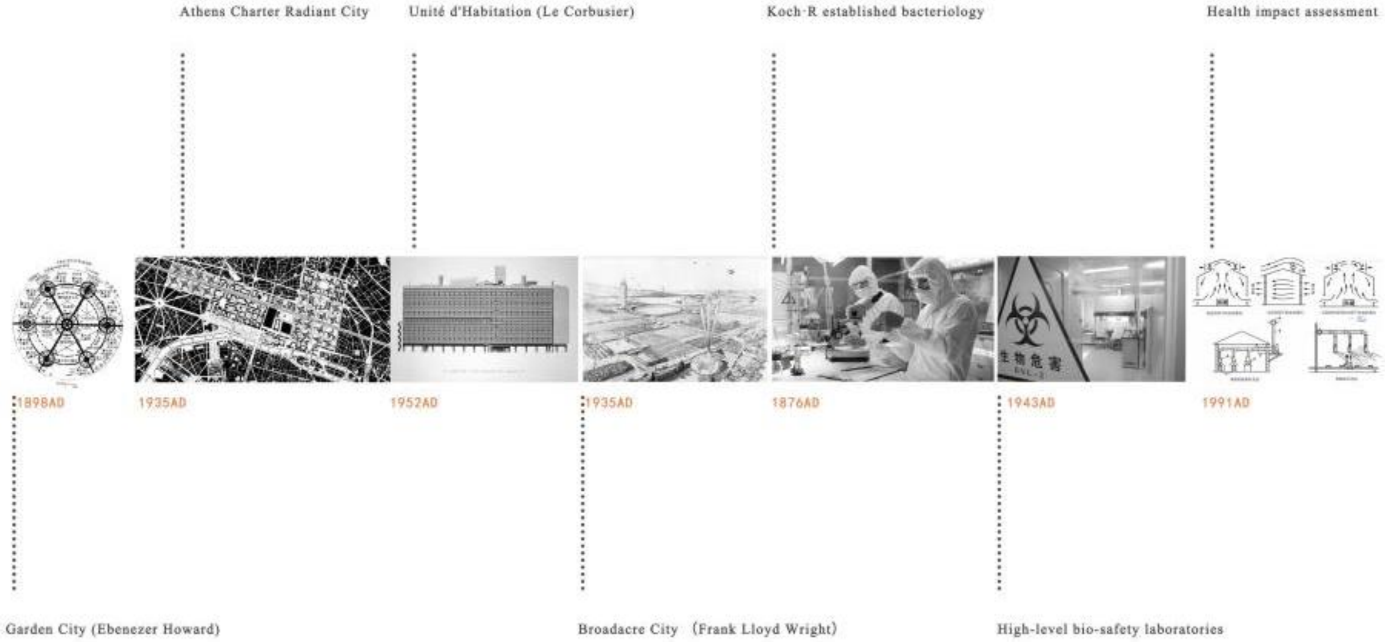

Figure 19. Spatial exploration from 1875 to present.

Source: Original work by the author integrating multidisciplinary sources, 2025. Historical data extracted from: Kenneth (1993), Robert (2020), Rosen (1958). Visual references include: Wikimedia Commons, Wellcome Collection.

Figure 20. Unité d'Habitation (Yishuzhizao, 2011).

During the formative years of Congrès Internationaux d'Architecture Moderne (CIAM), Le Corbusier redefined urban health infrastructure as a fundamental component of functionalist urban progression. His *Unité d'Habitation* (1949–1952, **Figure 20**), conceived as the second phase of his "Three Urban Stages" theory, aimed at providing high-quality collective housing for middle-income families. The key spatial design elements during this period include deconstructing functional elements, adopting open layouts, standardizing and modularizing components, establishing vertical systems and enhancing public interaction spaces.

During the late 19th and early 20th centuries, rapid industrialization and urbanization in the United States triggered what was termed the "industrial civilization syndrome". The focus of public health work has shifted toward holistic health, which aims to improve quality of life through modifying daily behaviors. As a pioneer of urban community reform, Laura Jane Addams founded Hull House in 1889 (**Figure 21**), transforming an 1856-built suburban residence in Chicago into a multifunctional community hub. It integrated childcare, daycare services, communal kitchens, recreational facilities and social clubs. By 1891, the complex expanded to include an art gallery and studios. By its fifth year, it comprised 15 buildings. Distinct from the chaotic "congested districts," Hull House provided communal spaces for leisure and socialization, introduced scientifically planned diets, addressed cultural and educational needs, and even established a vocational guidance center to assist the unemployed. This model prioritized both physical and psychological health, empowering residents to actively improve urban environments and sanitary conditions. Notably, during the 1902 summer epidemic, Hull House resident Alice Hamilton analyzed correlations between disease cases and plumbing systems, concluding decisively: "The outbreak was transmitted by flies." Furthermore, the facility constructed incinerators to mitigate risks from the city's inadequate waste collection infrastructure, effectively curbing diseases linked to food decay and garbage accumulation (Addams, 1910).

Figure 21. Hull house (Addams, 1910).

China accelerated biosecurity capacity building after the pandemics in 2003 and 2019. On 20 May 2020, the National Development and Reform Commission, in collaboration with two other ministries, promulgated the *Plan for Strengthening Public Health Prevention, Control and Treatment Capabilities*. The plan proposes to integrate resources from China CDC (Chinese Center for Disease Control and Prevention), research institutions and pharmaceutical enterprises, aiming to ensure that each province establishes at least one Biosafety Level 3 (BSL-3) laboratory, while encouraging the deployment of mobile Biosafety Level 2 (BSL-2) laboratories through coordinated efforts.

As critical infrastructure for researching hazardous pathogens and responding to emerging infectious diseases, biosafety laboratories have now established a mature organizational framework and protective technologies. The primary containment barrier refers to the isolation between the operator and the pathogen, achieved through biosafety cabinets, airtight containers and protective suits (**Figure 22**). The secondary containment barrier involves the isolation of the biosafety laboratory from the external environment, primarily relying on the laboratory's architectural structure, partition materials, ventilation and air filtration systems, water supply and drainage systems and sterilization equipment. In terms of spatial layout, the core operational zone is centrally located within the building and separated from the external environment by buffer zones, minimizing the risk of infection incidents (**Figure 23**) (Cao et al., 2019).

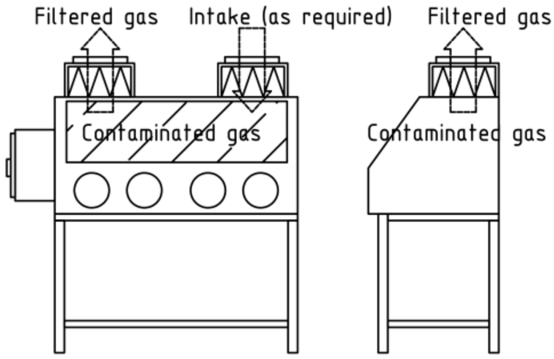

Figure 22. The primary containment barrier (Cao et al., 2019).

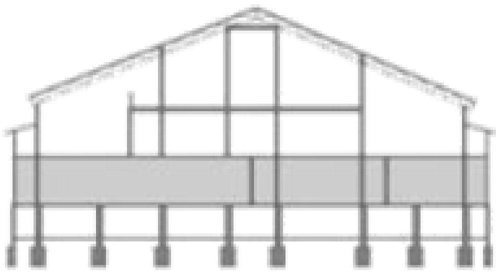

Figure 23. The secondary containment barrier (Cao et al., 2019).

4. Future spatial models—Data-driven multidimensional research

In 2009, Google engineers accurately predicted the outbreak of H1N1 influenza by analyzing web browsing data and established a model correlating specific search term frequencies with the spatiotemporal spread of infectious diseases (Mayer-Schönberger and Cukier, 2013). With the advent of the data-driven era, cities, as "augmented spaces" integrating modern intelligent technologies and networks, must shift their focus beyond ergonomics to the perception and utilization of spatial data (Lu and Dou, 2020).

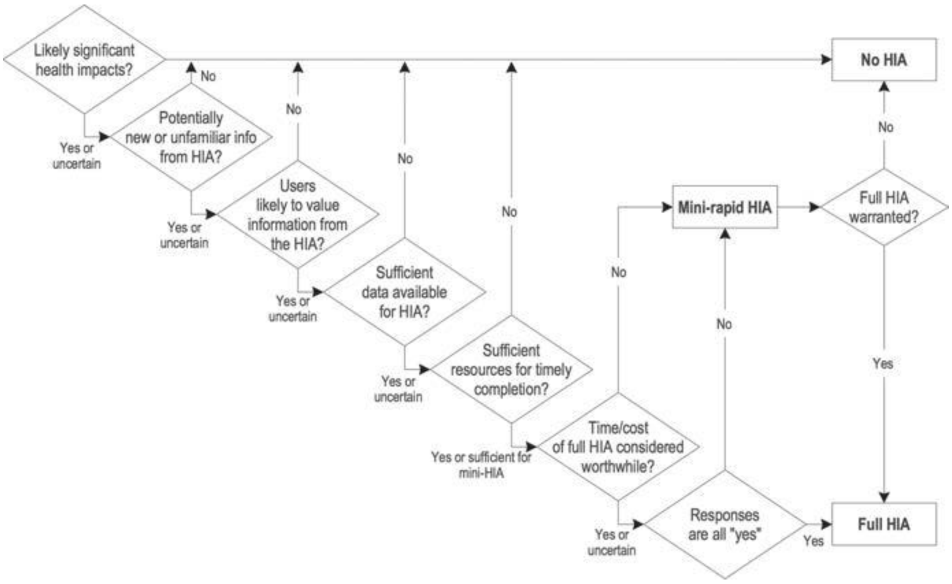

Figure 24. Example of a screening algorithm (Ross et al., 2014).

Today, common spatial evaluation tools, such as Health Impact Assessment (HIA), are used to identify the effects of environmental changes, policies, regulations and social behaviors on public health (**Figure 24**). These tools are further categorized into specialized frameworks like Health Equity Impact Assessment (HEIA), Mental Health Impact Assessment (MHIA) and Human Impact Assessment (HuIA), alongside metrics, such as Walk Score (WS), Traffic Noise Model (TNM) and Noise Annoyance Relationship (NAR) (Ross et al., 2014; Wang et al., 2022; Xiao and Li, 2021).

5. Discussion

"Healthy Building" is not a distinct architectural typology, but rather a convergence of solutions and humanistic considerations shaped by contextual knowledge and technological advancements. This paper constructs a theoretical model of "Concept-Technology-Space" (**Figure 25**):

- Pre-1500, early medicine attributed disease to divine punishment or disruptions in natural energies. Architectural efforts focused on creating safe sanctuaries that mimicked natural rhythms, aligning with airflows, water cycles, sunlight exposure and bathing practices.
- 1501–1875, The Renaissance era witnessed the rise of rational principles and systematic organization. Spaces began to isolate pathogenic factors through innovations like water supply/drainage systems, sanitation facilities and public health campaigns, leading to functional zoning.
- 1875-Present, following the Industrial Revolution, scientific advancements, such as the discovery of pathogens and immune mechanisms, enabled systematic deconstruction of health risks. As the concept of health has evolved to encompass diverse dimensions, spatial design has developed refined criteria and methodologies tailored to address multifaceted needs.
- In the future, information technology will redefine social interactions. Rigidly functional architecture has been dissolved. Meanwhile, daily behaviors are quantified as data, and spatial design now emphasizes multi-dimensional

evaluations based on sensory experiences.

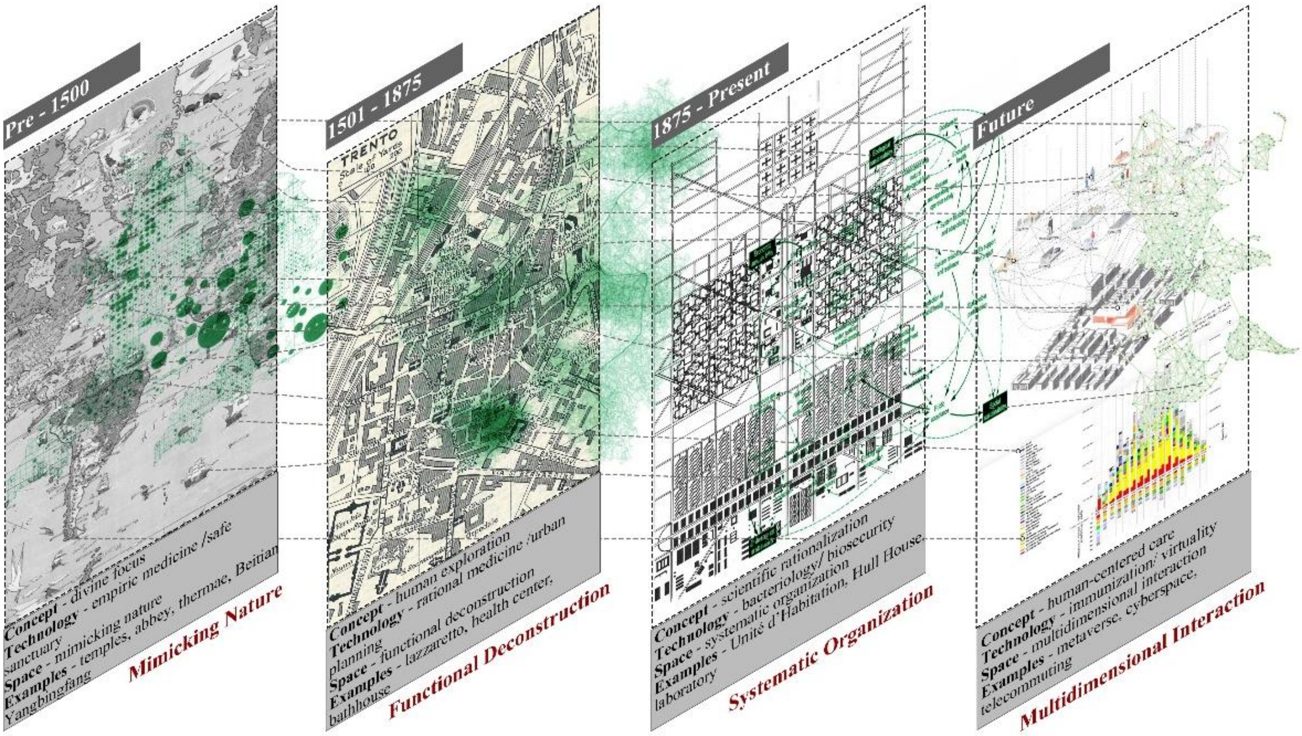

Figure 25. Diagram of spatial evolution across periods.

Source: Original work by the author integrating multidisciplinary sources, 2025. Historical data extracted from: Kenneth (1993), Robert (2020), Rosen (1958). Visual references include: Wikimedia Commons, Wellcome Collection.

Longitudinally, alongside the cognitive progression from "divine focus" → "human exploration" → "scientific rationalization" → "human-centered care". With the iterative refinement of technologies, spatial design has evolved along the trajectory of "mimicking nature" → "functional deconstruction" → "systematic organization" → "multidimensional interaction".

6. Conclusion

Plagues and Peoples mentioned that the core value of exploring the relationship between disease and historical development lies not in unearthing definitive historical truths, but in proposing provocative interdisciplinary frameworks that reshape scholarly inquiry (Valles, 2018; Wang, 2021). Post-pandemic academic reflections have catalyzed synergistic advancement across sociology, anthropology and medicine, and also compelled architectural discourse to re-examine canonical spatial prototypes from humanity's millennia-long struggle against pathogens. Such historiographical analysis, rooted in our current epistemic moment, promises to critically reformulate disciplinary paradigms for the coming two decades.

The revival of health-focused discourse in architecture extends beyond addressing pandemic-era isolation needs. Further, it emphasizes the guidance of daily health-conscious behaviors. Li Yu (2020) argues that architectural responses to health crises have been simultaneously reshaped by technological precision and entangled with digital intelligence since 2020. Spatial interventions should not be limited to emergency mobile hospitals or health-centric residential spaces, but must encompass cities and landscapes, and integrate cultural, technological and artistic dimensions.

Currently, refined spatial strategies for health-related issues are progressively advancing. Examples include Barrier-free spaces tailored to marginalized social groups, Interaction-oriented environments addressing communal living patterns in educational institutions and psychological well-being frameworks for elderly populations under home-based care models. These efforts aim to mitigate risks and reshape behavioral patterns through proactive design, ultimately forging a future-oriented blueprint for healthy habitats (Lin and Ma, 2021; Wang et al., 2020).

Author contributions: Conceptualization, JLL and TC; methodology, software, JLL; validation, JLL and TC; formal analysis, investigation, resources, data curation, writing—original draft preparation, JLL; writing—review and editing, TC; visualization, JLL; supervision, project administration, funding acquisition, TC. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

References

Addams, J. (1910). Twenty Years at Hull-House with Autobiographical Notes. New York, NY, USA: Macmillan.

Bai, Y. Z. (2021). Available online: http://ydyl.china.com.cn/2021-12/31/content_77961713_33.htm (accessed on 22 May 2025).

Cao, G., Tang, J., Wang, D., et al. (2019). Design and construction of biosafety laboratories. Beijing: Science Press.

Cheng, H. (2023). Research on Urban Spatial Injustice [PhD thesis]. Shanghai University of Finance and Economics.

Chicagology. (2021). Available online: https://chicagology.com/prefire/prefire021/ (accessed on 22 May 2025).

Debord, G. (1994). The Society of the Spectacle. Zone Books.

Dou, W. (1987). On Architectural Sociology. Journal of Architecture, (3), 67-70.

Engels, F. (1887). The Condition of the Working-Class in England in 1844. London, UK: S. Sonnenschein & Co.

Foucault, M. (1961). A History of Madness in the Classical Age (French). Paris: Plon.

Gao, X. (2019). Available online: https://worldscience.cn/zt/kxwh/604314.shtml (accessed on 22 May 2025).

Guan, Y. (2017). A Brief Analysis of Ancient Roman Civic Architecture in the Trajan Era. Research on Heritages and Preservation, 2(12), 61-65.

Guo, C., Lan, L., Xiong, T. (2024). Reflecting on the Design of Healthy Built Environments from a Historical Perspective in the Field of Public Health and Architecture. Architectural Science, 40(2), 19-29.

Hao, S. (2017). On Hippocrates’ Concept of Health [Master’s thesis]. Shaanxi Normal University.

Hippocrates. (1526). De Aere, Aquis et Locis. Venice: Aldus Manutius.

James. (1866). Available online: https://chicagology.com/prefire/chicagoillustrated/1866jan02/ (accessed on 22 May 2025).

Kiple, K. F. (1993). The Cambridge World History of Human Disease. Cambridge University Press.

Lefebvre, H. (1974). La production de l’espace. L Homme et La Société, 31(1), 15–32. https://doi.org/10.3406/homso.1974.1855

Li, Y. (2020). 3 Combinations of Public Health and Architecture. Architectural Creation, 2020(4), 30-37.

Lin, H., Ma, P. (2021). InSAR Monitoring Methods and Applications for Urban Infrastructure Health. Beijing: Science Press.

Locke, J. (1975). An Essay Concerning Human Understanding. Oxford: Oxford University Press.

Lu, A., Dou, P. (2020). Extreme versus Regular: Questions of New Human Habitat in Post-2020 Era. Journal of Architecture, 2020(S1), 28-33.

Lü, C. (2022). Creation in Flux: The “Furnace Diagram” from Mawangdui and Theories of Life Casting in Early China. Art Panorama, 12, 99-106.

Mayer-Schönberger, V., Cukier, K. (2013). Big Data: A Revolution That Will Transform How We Live, Work, and Think. Boston, MA, USA: Houghton Mifflin Harcourt.

Ou, X., Wang, W., Ma, M. (2023). On the Historical Development and Evolution of Mobile Architecture from the Perspective of ‘Society-Space’ Interaction. Architecture and Culture, (9), 200-202.

Park, R. E., Burgess, E. W., & Mckenzie, R. D. (1925). The city: Suggestions for investigation of human behavior in the urban environment. Chicago: University of Chicago Press.
Qi, Z. (2006). A brief discussion on the Beitian Yangbingfang (charitable hospices) in the Tang Dynasty. Journal of Xi'an University of Arts and Science (Social Sciences Edition), 9(1), 37 -39.
Richardson, B. W. (1876). Hygeia: A City of Health. London: Macmillan and Co.
Rosen, G. (1958). A history of public health. MD Publications.
Ross, C. L., Orenstein, M., Botchwey, N. (2014). Health Impact Assessment in the United States: Theory, Methods, and Case Studies. Washington, DC, USA: Island Press.
Tang, K. (2022). The Idea and Generation of "Innovation Space: An Architectural Sociology and Its Related Practice." Creativity and Design, (5), 11-19.
Tyng, A. (1984). Louis I. Kahn: The Philosophy of Order. New York: Rizzoli International Publications.
Valles, S. A. (2018). Philosophy of Population Health: Philosophy for the New Public Health Era. London, U.K.: Routledge.
Vaneigem, R. (1983). The Revolution of Everyday Life. London: Left Bank Books.
Vitruvius. (1914). The Ten Books on Architecture. Harvard University Press.
Wang, J. (2021). Research on Cognitive Development of Design Based on Building Health and Safety. Urbanism and Architecture, 18(35), 145-147, 195.
Wang, J. G., Zhuang W. M., Meng J. M., et al. (2020). Group Discussions: Contemporary City, New Human Habitat, and Architectural DeSsign. Journal of Architecture, 2020(S1), 2-27.
Wang, Q., Meng, C., Zhang, Y., et al. (2018). Development concept, status and trend of healthy building in China. China Construction Industry Press.
Wang, T., Zhang, S., Wu, T. (2022). Orderly Operation, Organic Growth: Construction of a Prevention and Control System for Public Health Emergencies. Contemporary Architecture, 2022(5), 130-133.
WIKIMEDIA COMMONS. (2018). Available online https://commons.wikimedia.org/wiki/File:Hippocrates_bust_and_title_page_Wellcome_L0041093.jpg (accessed on 22 May 2025).
Winslow, C. E. A. (1920). The Untilled Fields of Public Health. Science, 51(1306), 23–33. https://doi.org/10.1126/science.51.1306.23
Xiao, H., Li, H. (2021). Active Intervention and Its Strategies of Health Impact Assessment (HIA) on Landscape Architecture Planning and Design. Journal of Western Human Settlements, 36(2), 69-77.
Xu, Z., Hu, X., Zeng, D. (2018). Environmental Risk: Environmental Decision-Making Under Uncertainty. Beijing: China Environmental Publishing Group.
Yishuzhizao. (2011). Available online: http://www.capablist.com/uc/3759271 (accessed on 22 May 2025).
Zhang, L. (2016). Active Health: Human Body, Leisure and Playfulness of Public Space. World Architecture, (11), 16.