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Promoting sustainable health and safety in post-pandemic disaster risk management in Istanbul, Turkey

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In line with Sustainable Cities and Communities (SDG 11), the COVID-19 pandemic has exposed the vulnerabilities of urban environments, emphasizing the critical need for robust strategic planning. Effective strategies are essential for mitigating the impacts of pandemics, enhancing the city's resilience, and safeguarding the wellbeing of city inhabitants. Thus, more strategic measures are needed to ensure the health and safety of urban populations for future occurrences. This empirical study explores how environmental planning practices can mitigate health risks, especially in the post-COVID-19 pandemic era in Turkey. The study objectives include i) investigating factors influencing the built environment and the reduction of public health risks in the wake of the COVID-19 pandemic, and ii) exploring adaptable methods to improve the built environment in the wake of the COVID-19 pandemic. The results of the responses were assessed through Structural Equation Modeling (SEM) analysis of the SmartPLS four program. Results indicated positive path significant values of <0.005 to build community resilience after the post-COVID-19 pandemic. Other significant factors include sustainable built environment practices; Public Health risks, Sustainable City Planning; and Public Health improvement strategies. The positive relationships suggest that these factors are critical in promoting a sustainable COVID-19 pandemic-free built environment in the future. Findings emphasize the importance of incorporating these significant variables into environmental planning and design as a strategy to achieve improved public health and an adaptable built environment.

KEYWORDS

disaster risk management, post-COVID-19 pandemic, public health risk, sustainable practices, healthy environment, sustainable city, built environment

1 Introduction

The COVID-19 pandemic has underscored the critical need for integrating sustainable health and safety measures into disaster risk management frameworks (Jayasinghe, et al., 2024; DeWit, et al., 2020; Afrin et al., 2021). City environments, with their dense populations and complex infrastructures, are particularly vulnerable to public health crises, necessitating innovative strategies that prioritize resilience and sustainability (Capolongo, et al., 2020). Sustainable approaches to health and safety in post-pandemic recovery involve mitigating immediate risks and addressing systemic vulnerabilities in city planning, healthcare systems, and social structures (Brundtland, 1987). Cities are susceptible to a variety of pressures, including disasters that are both natural and man-made, because of the great number of

inhabitants and activity there. Socioeconomic factors significantly shaped the COVID-19 pandemic's development and its global spatial differentiation. Disparities in wealth, healthcare access, and living conditions influenced infection rates, mortality, and recovery outcomes, resulting in varied impacts across regions. These disparities underscore the need for equitable public health strategies and resource allocation in managing global health crises (Bański, et al., 2021; Damián, et al., 2022).

The advent of the COVID-19 pandemic posed an unparalleled obstacle to city environments globally, intensifying the need for strategic planning to ensure public health, safety, and resilience (DeWit, et al., 2020; Mitrică, et al., 2022). The spread of the virus in city spaces, especially in high-density regions has had a great impact, and it demonstrated how unprepared built environments have been for pandemics and gave an indication that there is a need for the overhaul of city planning (Güner et al., 2020; Afrin et al., 2021). Global organizations like UN-Habitat and the WHO have echoed the COVID-19 pandemic's call to action, which emphasizes the urgent need for better planning and healthcare integration, as well as the connections between the structure of city growth and the wellness of populations (UN-Habitat, 2021b). This renewed interest in environmental design is a major public health facilitator to enhance global support for the Healthy Cities movement. This is to support the claim that environmental planning can reduce health inequities (WHO, 2020).

While responding to the COVID-19 issue; Mitrică, et al. (2021); succinctly contributed that a focused methodological approach can improve pandemic response by steering decision-makers toward customized, region-specific solutions. This strategy helps reduce economic impacts by engaging local and regional stakeholders in pinpointing effective interventions. Furthermore, the methodological approach fosters social cohesion by tackling population vulnerabilities and enhancing health infrastructure, especially in underprivileged areas (Bucos, 2024).

Before the normalization phase, Turkey recorded over 20,000 COVID-19 tests, 4,540 fatalities, 127,973 recoveries, and 163,942 confirmed infections (The Ministry of Health, 2020). The COVID-19 pandemic exposed vulnerabilities within city areas, particularly in high-density settings such as Istanbul (15.84 million); Ankara (5.7 million); İzmir (4.3 million); Konya (2.3 million), where environmental challenges heightened transmission risks (Conway, et al., 2023; WHO, 2022). Studies reveal that cities worldwide faced a host of challenges, which exacerbated the spread of COVID-19 (Corbera, et al., 2020; Torun, 2020). Thus, the pandemic has underscored the importance of addressing critical vulnerabilities in city spaces, such as access to a healthy environment, which plays a pivotal role in promoting public health and wellbeing.

Public health objectives play a vital role in community disaster risk management by emphasizing the prevention, mitigation, and response to health threats arising from natural and man-made disasters (Agboola, 2011; DeWit, et al., 2020). It includes reducing vulnerabilities, enhancing healthcare accessibility, and promoting community resilience through preparedness initiatives (Afrin et al., 2021; Mitrică, et al., 2022). Integrating these goals into disaster risk management frameworks ensures a proactive approach to addressing the social determinants of health, which are critical in shaping community outcomes during crises. Moreover, sustainable city planning and green infrastructure have emerged as essential tools for mitigating the health impacts of disasters, particularly in densely populated city areas (Barton and Grant, 2006; Jayasinghe, et al., 2024). By prioritizing public health in disaster response strategies, communities can build resilience, reduce health disparities, and enhance recovery outcomes. This alignment between public health and disaster management fosters safer, healthier environments that are better equipped to handle future challenges (Brundtland, 1987).

The literature indicates that there may be a positive relationship between sustainable built environment practices and reduced public health risks as well as the benefits of integrating public health objectives into urban planning (DeWit, et al., 2020); there remains a significant research gap in quantifying these relationships, especially within specific contexts during crises like COVID-19 in Istanbul, Turkey. This study aims to address the research gap by experimentally exploring the factors and strategies that can enhance the resilience of Turkey's urban environments. By linking pandemic preparedness with sustainable practices, the research provides a practical framework for improving city health resilience. The study's objectives are two-fold.

(i) Identify factors influencing the sustainability of the built environment and public health risks in the wake of COVID-19, and
(ii) Explore adaptable methods to improve the built environment in the wake of the COVID-19 pandemic.

This study emphasizes the importance of leveraging green infrastructure, sustainable city design, and robust public health systems to enhance disaster preparedness and response. By aligning with global objectives such as SDG 11 (Sustainable Cities and Communities), the research provides actionable insights for creating resilient city spaces. Addressing these challenges requires a multidisciplinary approach, integrating principles of sustainability and health to reduce risks and ensure long-term community wellbeing. The novelty of the study lies in its focus on the synergistic relationship between city design and pandemic preparedness, offering innovative strategies that go beyond conventional approaches. The study provides actionable insights for designing healthier, more resilient city environments in the face of future health crises.

2 Study area and its characteristics

Straddling two continents Europe and Asia Istanbul's geographical location alone establishes it as a dynamic hub of activity, connecting diverse cultures and economies (Burdett, 2009). Istanbul (Figure 1) exemplifies the challenges and opportunities encountered by rapidly urbanizing cities around the globe. Its distinctive geographical location, rich historical background, diverse population, and vibrant economic landscape make it an excellent case study for exploring sustainable urban development. Additionally, Istanbul's climate is categorized as a transitional Mediterranean climate, characterized by hot, dry summers and cool, wet winters (Turkes, 2020). This climatic variability brings both opportunities and challenges for urban sustainability. On the other hand, climate change is exacerbating weather extremes, leading to

FIGURE 1
Map of Istanbul. Source: Google map.

problems such as urban heat islands, flooding, and air pollution. The city's strategic location along the Bosporus Strait, connecting the Black Sea to the Mediterranean, has historically positioned it as a vital gateway for trade and cultural exchange between East and West. Geographically, Istanbul is split by the Bosporus into its European and Asian sides, each displaying unique characteristics. The European side is typically more densely populated and is home to many of the city's administrative, commercial, and historical centres, while the Asian side features a mix of residential areas, emerging business districts, and more suburban developments. This division not only shapes the city's physical layout but also impacts its transportation networks, urban planning strategies, and socio-economic dynamics.

Istanbul boasts a large and diverse population, with estimates suggesting it exceeds 15 million residents, making it one of the largest cities globally (Bayraktar, et al., 2024). This extensive population is a blend of various ethnicities, religions, and cultural traditions. This cultural richness enhances social life and presents unique challenges and opportunities for urban governance, public policy, and community development. Istanbul's urban landscape is intricate and multifaceted. Several efforts have focused on Istanbul's sustainable urban development and the need to consider preserving historical heritage while addressing the demands of rapid growth and modernization. Furthermore, Istanbul's infrastructure plays a vital role in shaping its urban character and functionality. The city features a well-developed transportation network, which includes a wide-ranging bus system, metro lines, trams, and ferries that link its two sides. Nevertheless, traffic congestion continues to be a significant issue, especially on the densely populated European side. The demand for sustainable infrastructure solutions is becoming increasingly clear, as urban planners work to find a balance between growth, environmental sustainability, and social equity.

3 Conceptual framework

The theoretical framework underpinning this research is built on the integration of sustainable development theory and public health theory, providing a multidimensional lens for addressing city and environmental challenges (Baker et al., 2017; Hariram, et al., 2023). Public health theory emphasizes the significant influence of environmental factors on health outcomes (DiClemente, et al., 2013); particularly in city areas where living conditions directly impact community wellbeing. It underscores the importance of

addressing these environmental determinants to promote healthier populations. On the other hand, sustainable development theory, as articulated in the Brundtland Report (1987), advocates the creation of systems that satisfy current demands without endangering the capacity of future generations to satisfy their own.

By merging these theories, the framework suggests that integrating public health goals into city planning and architectural practices can foster healthier communities while advancing sustainability. This holistic approach is supported by concepts like the Social Determinants of Health, which link socioeconomic conditions and the built environment to health outcomes (Marmot, 2014; Afrin et al., 2021). Furthermore, Barton and Grant's health map model (2006) reinforces the interconnectedness of health and environmental variables, emphasizing the necessity of embedding health considerations into planning and design processes. The novelty of this framework lies in its application to current public health crises, such as COVID-19, by demonstrating how sustainable architecture and city planning can mitigate health risks. By aligning health and sustainability objectives, this research provides actionable insights for creating resilient city environments capable of addressing both immediate and long-term health challenges.

The research framework serves as a comprehensive visual guide, offering a holistic overview of the research process from conceptualization to conclusion while emphasizing methodological rigour and ethical integrity. Figure 2 provides a detailed representation of this framework, outlining the key components that structured the investigation. It begins with the study's objectives, focusing on the exploration of sustainable built environment practices and their impact on public health and city resilience (Capolongo, et al., 2020; Afrin et al., 2021). The framework also integrates hypotheses grounded in the relationships between critical variables such as green spaces, city infrastructure, and health outcomes. The methodological design is clearly illustrated, showcasing the robust approach employed for data collection and analysis, ensuring alignment with the study's aims and contextual relevance. Furthermore, the framework underscores the adherence to standard ethical protocols, including securing participant consent and ensuring data privacy, which bolsters the research's credibility and validity. This structured approach highlights the thoroughness of the research process, ensuring a clear pathway from initial objectives to conclusions while maintaining ethical and methodological rigour throughout.

4 Hypothesis development and variable measurements

4.1 Sustainable built environment practices and public health

The built environment significantly influences public health outcomes, especially in the context of the COVID-19 pandemic (Frumkin, 2021; Alidadi and Sharifi, 2022). Existing literature emphasizes the relationship between city design, building ventilation, and disease transmission. Poorly ventilated spaces have been linked to higher infection rates, as evidenced by studies showing that adequate air circulation can mitigate airborne pathogen spread (Krause et al., 2021). Moreover, city layouts that prioritize density without adequate public health considerations may exacerbate disease transmission, as crowded spaces facilitate close contact among individuals (do Amaral, et al., 2024). The pandemic has prompted researchers to advocate for the integration of health-focused strategies in architectural design, emphasizing the importance of outdoor spaces and green infrastructure to enhance mental wellbeing and reduce stress (Marques, et al., 2021).

Addressing these public health concerns within the built environment is critical to improving community resilience against current and future health crises (Capolongo, et al., 2020). Issues such as land degradation (McPherson, 2005), biodiversity loss (Ejike-Alieji and Ekpoh, 2021), and pollution (Agboola et al., 2024) significantly impact community health. The interplay between the COVID-19 pandemic and public health is evident, as extreme weather events exacerbate health issues, threatening food security, water availability, and socioeconomic development (Torun, 2020; WHO, 2022). To promote resilience in vulnerable populations, there is an urgent need for integrated strategies that address climate-related health threats within the built environment. This includes ensuring that city design incorporates sustainable practices that prioritize public health outcomes, especially in the wake of COVID-19.

Implementing sustainable architectural practices, such as green building materials and energy-efficient designs, can lead to healthier city environments. These practices may mitigate the adverse effects of the COVID-19 pandemic, thereby enhancing public health. Evidence from various studies suggests that sustainable architecture contributes to better health outcomes by promoting physical activity, lowering heat island effects in cities and enhancing the quality of the air through well-designed public spaces (Geng, et al., 2020; Baker, et al., 2017; Agboola, 2019). When it comes to managing the COVID-19 pandemic, resilient built environments are essential. To prevent the spread of viruses and protect human health, indoor air quality must be addressed by lowering biological pollutants and household pollution (Elsaid, et al., 2021). Air quality is improved and public health is supported by controlling ambient air pollution by reducing emissions from operations and construction materials (Nnaji, et al., 2023). Maintaining water quality through routine testing, cleansing, and efficient water management lowers the risk of infection and encourages cleanliness. Psychological resilience over extended periods of isolation is supported by improving mental and social health through biophilic design, communal areas, and natural access (Agboola et al., 2015). Using UV disinfection, cleaning high-touch surfaces, installing building sensors, and maintaining HVAC systems are all crucial ways to prevent the spread of disease (Kalbasi and Hassani, 2022). These actions improve pandemic response and readiness. COVID-19 Disaster Management Strategies for Healthy and Sustainable Environments as presented in Figure 3.

- Thus, H0 (Null Hypothesis): In urban environments, sustainable built environment practices do not have a significant positive impact on reducing public health risks.
- H1 (Alternative Hypothesis): In urban environments, sustainable built environment practices have a significant positive impact on reducing public health risks.

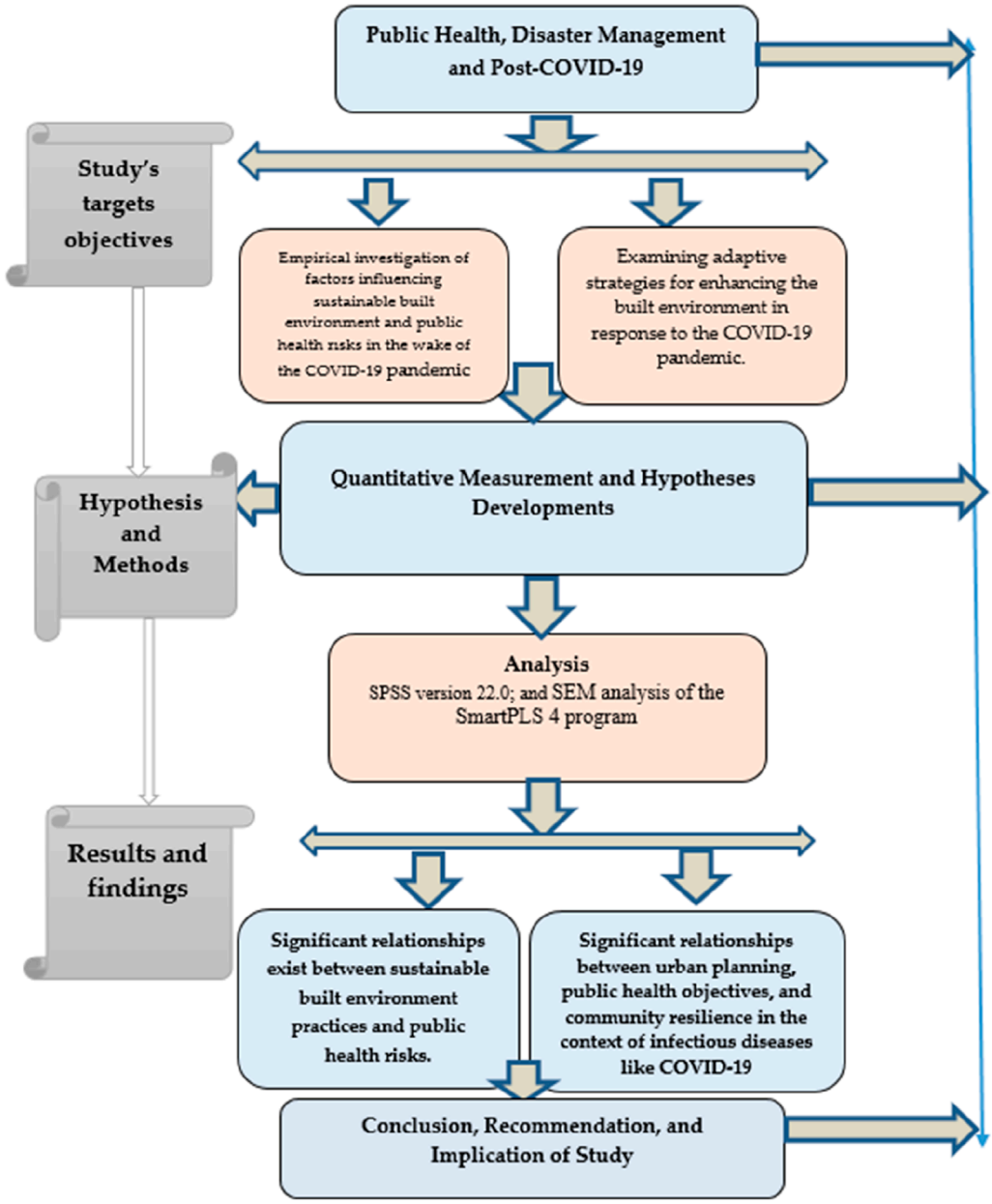

FIGURE 2
The study's framework.

This hypothesis guides the empirical investigation and contributes to the understanding of how public health and sustainability can be effectively intertwined within the built environment. While previous literature suggests a positive link between sustainable built environment practices and reduced public health risks as well as benefits from integrating public health objectives into urban planning; a significant gap remains in quantifying these relationships, especially in crisis contexts like COVID-19. The null and alternative hypotheses are designed to statistically test these associations, thereby confirming or challenging existing preliminary findings and uncovering context-specific variables that have yet to be fully explored. This empirical approach rigorously validates these relationships, offering new insights into sustainable urban development and community resilience. The variables in Table 1 present measurement variables of sustainable built environment practices and public health.

4.2 Community disaster risk management and public health

Sustainable architectural practices and smart city planning are critical to effective community disaster risk management, as they enhance resilience through efficient resource use, waste

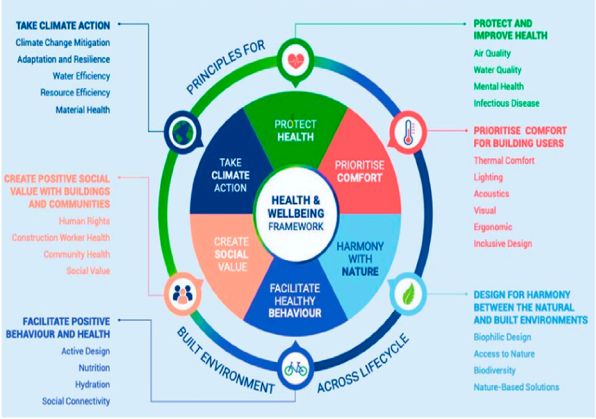

FIGURE 3
Guidelines for a sustainable and healthful built environment.
Source: Magsino (2023).

reduction, and improved quality of life (Jayasinghe et al., 2024; DeWit et al., 2020). For example, incorporating green roofs and urban green spaces supports biodiversity and improves air quality (Joshi and Teller, 2021); while also reducing reliance on vehicles, lowering greenhouse gas emissions, and promoting physical activity (Ewing et, al., 2011). Additionally, strategies such as natural ventilation and daylighting improve indoor air quality and occupant wellbeing. Integrating public health objectives into urban planning is particularly crucial in light of challenges like COVID-19. Meanwhile, energy-efficient building designs reduce emissions, energy consumption, and the inclusion of green spaces. This not only enhances biodiversity but also supports mental wellbeing by providing recreational areas (Kaplan and Kaplan, 2011). Urban design features that facilitate social distancing, such as wider sidewalks, pedestrian-only zones, and open-air markets, help mitigate the spread of infectious diseases while fostering social cohesion (Witten and Ivory, 2018). Moreover, natural lighting, environmentally friendly materials, and better ventilation systems all help to improve the quality of indoor air, reducing respiratory illnesses and enhancing overall health (Roberts, et al., 2022). Integration of sustainable design and public health measures creates resilient urban environments capable of withstanding both immediate and long-term challenges. Research shows that cities with strong public health frameworks and ample green spaces tend to achieve better health outcomes and adaptability during crises (Jiang et al., 2021; Barton and Grant, 2006). This holistic approach is essential for developing sustainable communities in an increasingly uncertain world.

- Thus, H0 (Null Hypothesis): In the context of crises such as COVID-19, integrating public health objectives into urban planning does not lead to significant improvements in environmental sustainability and community resilience.
- H2 (Alternative Hypothesis): In the context of crises such as COVID-19, integrating public health objectives into urban planning could lead to significant improvements in environmental sustainability and community resilience.

This null and alternative hypothesis was formulated after a literature review revealed persistent gaps in the understanding of how sustainable built environment practices and the integration of public health objectives impact urban resilience and community wellbeing, especially during crises such as COVID-19. While past studies have indicated positive associations (Lee, et al., 2022; Sallis, et al., 2021), few have quantitatively validated these relationships within specific, resource-constrained urban settings. By statistically testing the proposed hypotheses, the study bridges the divide between qualitative insights from previous research and the need for quantitative validation. This approach not only confirms or challenges established theories but also contributes novel insights regarding the key drivers of sustainable urban development and public health outcomes. The variables in Table 2, showcase the measurements of city planning, public health strategies, and community resilience efforts post-COVID-19.

4.3 Global efforts towards post-pandemic urban planning and resilient cities

The COVID-19 pandemic has had a profound effect on urban planning, prompting a necessary shift towards resilience and sustainability in our cities. In the wake of the pandemic, urban planning now focuses on adaptability, public health, and sustainability, ensuring that cities are better equipped to handle future crises (Pacheco, et al., 2024; Chen and Li, 2024). Key principles guiding post-pandemic urban policies include the integration of digital infrastructure, green spaces, and mixed-use developments (Honey-Rosés et al., 2021; Moghaddam, 2024). Furthermore, cities are placing a greater emphasis on walkability, decentralizing services, and implementing flexible zoning regulations to better accommodate evolving work and mobility patterns (Naimi et al., 2024).

A crucial element of resilient city planning is the improvement of public health infrastructure. The pandemic highlighted the need for urban designs that support social distancing while also ensuring accessibility and equity (Pacheco, et al., 2024). Smart city solutions, such as AI-driven monitoring systems and data-informed decision-making, have been increasingly adopted to enable swift responses to future public health challenges (Martinez-Mireles, et al., 2025). In addition, economic resilience has increasingly become a key focus in urban planning strategies. By diversifying local economies, providing greater support for small businesses, and investing in green infrastructure, cities can achieve both economic stability and environmental sustainability (Umoh, et al., 2024). Thus, incorporating nature-based solutions like urban forests and rainwater management systems strengthens cities' ability to withstand climate-related disruptions.

4.4 Comparative analysis of global post-pandemic urban resilience strategies

The COVID-19 pandemic has triggered profound transformations in urban life, altering mobility patterns, reshaping urban governance, and redefining pandemic response strategies. These shifts have raised critical questions about contemporary

TABLE 1 Measurement variables of sustainable built environment practices and public health risks.

Major themes	Sub-themes	Explanations	References
Sustainable Built Environment Practices Variables	Sustainable Waste and Water Management Practices	Waste and water management systems contribute to a sustainable built environment	Roy, et al. (2023)
	Green Building Technologies	Green building technologies integrate to reduce environmental impact and promote sustainability	Kibert, (2016); Almusaed, et al. (2024)
	Urban Green Spaces	Urban green spaces play in enhancing sustainability and public health	Kabisch et al. (2017)
	Air and Water Quality Management	Water quality management practices in urban areas contribute to a sustainable built environment	EPA (2020)
	Active and Sustainable Transportation Systems	A degree in sustainable transportation systems (like biking, walking, and public transit) supports environmental sustainability	Gössling (2020)
	COVID-19 pandemic and Resilience	The status of COVID-19 pandemic mitigation and resilience strategies incorporated into urban planning are paramount	Lak, et al. (2020); Bahukhandi, & Saraswat, (2023)
	Urban Planning and Green Infrastructure	Integrating green infrastructure into urban planning supports sustainability and environmental resilience	Acar, S. (2021)
Public Health Risk Variables	Waterborne and Infectious Diseases Spread	The level of impact of poor water management on the spread of infectious diseases in urban environments	WHO, (2020)
	Inadequacy of Ventilation and Indoor Air Quality	Inadequate ventilation and poor indoor air quality in residential spaces affect public health	Mannan, & Al-Ghamdi, (2021)
	Inaccessibility to Safe and Secure Housing Conditions	How does the lack of access to safe, secure housing conditions contribute to public health risks?	Sharpe, et al. (2018)

planning approaches for resilient urban structures, extending beyond cities to include hinterlands, regional hubs, and rural centres (Alam and Nel, 2023; Swapan et al., 2023). Thus, Cities around the globe have adopted a variety of strategies to address the challenges of urban resilience in the post-pandemic era. For instance, New York City has concentrated on bolstering its healthcare system, increasing bike lanes, and encouraging outdoor dining to aid in economic recovery and enhance public health (Mesa, 2021).

In a similar vein, Singapore has utilized its smart city initiatives to improve contact tracing technologies and streamline urban logistics, ensuring essential services remain operational (Carpentiere, et al., 2024). In Europe, cities like Paris and Milan have embraced a significant new model in the global conversation about post-pandemic urban resilience the "15-min city concept", which aims to minimize reliance on long commutes while boosting local economies and promoting sustainability (Moreno, et al., 2021; Allam, et al., 2023). This model highlights the benefits of compact urban design, encouraging closer access to essential services while focusing on pedestrian accessibility rather than car dominance. These cities have reconfigured their urban layouts to make essential services, workplaces, and recreational areas easily accessible within a short walk or bike ride. These insights from Europe offer valuable lessons for shaping national and regional development strategies. Ultimately, this approach equips stakeholders to strengthen governance at all levels, ensuring more adaptable, efficient, and responsive urban planning in the face of future pandemics.

As the idea of smart cities becomes more popular, the COVID-19 pandemic has changed urban life, prompting a re-evaluation of urban models and infrastructure priorities, including the core principles and key indicators of smart city frameworks. For instance, in Asia, Tokyo has responded by enhancing public health measures and reconsidering how urban density is managed (Srinivasan, et al., 2024). The city's post-pandemic planning has involved redesigning office spaces and encouraging hybrid work models, which helps to alleviate congestion and build resilience against future disruptions. Similarly, Seoul has expanded its green spaces and pedestrian-friendly zones to promote both mental and physical wellbeing (Kim and Gong, 2024). In a similar vein, African cities have encountered distinct challenges, such as inadequate healthcare

TABLE 2 Measurement variables of city planning, public health objectives, and community resilience.

Major themes	Sub-themes	Explanations	References
City Planning Variables	Access to Green Spaces	Accessible to green spaces in urban areas for physical and mental health benefits	Sugiyama, et al. (2018)
	Sustainable Infrastructure Development	Sustainable infrastructure is integrated into urban planning to enhance public health and environmental sustainability	Şahin, et al. (2020)
	Transportation Systems	Urban planning promotes active transportation systems (cycling, walking) to enhance health and reduce pollution	Wang, et al. (2020); and Afolabi, & Adedire, (2023)
	Housing Density Regulations	Housing density regulations affect the spread of infectious diseases	WHO (2020)
	Urban Heat Island Mitigation	Urban designs reduce heat island effects and improve public health outcomes	Geng, et al., 2020; Baker, et al., 2017
Public Health Objectives Variables	Integration of Public Health in Urban Planning	The effectiveness of public health goals integration into urban planning strategies	Barton, & Grant, (2006)
	Emergency Response Infrastructure	Robustness of the infrastructure manages public health emergencies in urban areas	Watson, et, al., (2020)
	Air Quality Management	Air quality improvement measures integration to protect public health	WHO (2020)
	Water and Sanitation Access	Accessible clean water and sanitation services improve urban populations' coordination	Cooper, (2020)
	Health Facility Accessibility	Accessible healthcare facilities and services improve urban residents' wellbeing	WHO (2020)
Community Resilience Variables	Community Engagement in Planning	Communities' involvement in urban planning decisions positively affects residents' resilience and health	Capolongo, et al. (2020)
	Public Awareness Campaigns	Public awareness campaigns promote resilience and health behaviours after COVID-19	WHO (2020); Capolongo, et al. (2020)
	Social Support Networks	Local social support systems aides recovery and resilience at the post-pandemic period	Capolongo, et al. (2020)
	Economic Recovery Initiatives	Economic initiatives support communities' financial stability and resilience after the pandemic	Mitrică, et al. (2022)
	Adaptive Capacity to Future Crises	Well-preparedness of the community for adapting to future health crises based on lessons learned from COVID-19 are important	He, & Zhang, (2023)

infrastructure and economic vulnerabilities. For example, in Lagos one of the major cities in Nigeria, the focus has been on digital transformation and urban mobility, with efforts to expand telehealth services and invest in flexible transportation systems to enhance accessibility (Olaniyi and Ajayi, 2024). Also, Cape Town has prioritised social housing reforms and community-driven resilience initiatives to tackle inequalities in urban planning (Foggitt, 2021; Chekero, (2025). Global response to these challenges without the

exception of Turkey as a developed nation calls for urban resilience in the post-pandemic by adopting flexible strategies. Cities that effectively combine digital technology, green infrastructure, and inclusive urban policies have demonstrated enhanced resilience against current and future challenges (UN-Habitat, 2021a). The diverse approaches reveal the core principles of sustainability and adaptability that are fundamental to urban resilience planning in recent times.

5 Methods

This study uses a quantitative methodology, which entails gathering and analyzing numerical data to systematically investigate phenomena. (Creswell and Creswell, 2018). The research method is designed to systematically investigate the integration of public health objectives and sustainable practices in the built environment during and beyond COVID-19, employing rigorous quantitative techniques to support the study's objectives. The quantitative approach allows for the testing of hypotheses and the establishment of statistical relationships among variables (Mohajan, 2020). This method is particularly effective in assessing the impact of integrating public health objectives with sustainable built environment practices, as it provides a framework for measuring outcomes and drawing conclusions based on empirical evidence. Data collection is done based on responses to structured questionnaires that contain closed questions and scaled questions, from which stakeholders' perceptions and experiences are noted. These instruments were developed based on literature reviews and expert inputs to ensure reliability and validity (Lamm, et al., 2020). In addition to primary data collected from surveys, secondary data is sourced from Turkish government online platforms, including agencies, divisions, and other appropriate authorities in charge of issues about health, and the built environment in cities. (Mengu, et al., 2021). This offers a thorough comprehension of the background and current frameworks about the study issue.

Secondary sources include reports, articles from national and public organizations, and relevant national newspapers, which will enrich the data set and provide diverse perspectives on the integration of public health and sustainability (OECD, 2021). The targeted population consists of architects, city planners, university lecturers, and public health officers actively involved in city development in Istanbul, Turkey as previously adopted by Baker et al. (2017). To ensure a representative sample, random sampling was utilized, allowing for the selection of participants from various regions and backgrounds (Creswell and Creswell, 2018). This method minimizes bias and enhances the generalizability of the findings. By obtaining a diverse sample of professionals, the research aims to capture a wide range of insights regarding the integration of health and sustainability in city planning and architectural practices.

A random sampling strategy ensures diversity, reducing bias and increasing the generalizability of findings. Structured questionnaires systematically collect data relevant to the subject matter under investigation and may offer valuable insights into health-sustainability dynamics in city and architectural practices. A validation survey of 15 experts tested the practical applicability of the structural model, enriching the study with professional perspectives. A total of 206 responses were collected for analysis through an online survey using convenience sampling between February and May 2023. The convenience sampling method was utilized because comprehensive professional lists were not available; this methodology has also been suggested by Creswell, & Creswell, (2018); and other researchers. Structural Equation Modeling (SEM) and SPSS version 22.0 were used to examine the responses; utilizing the current version of SEM for a more advanced and accurate analysis. SEM was employed to examine the relationships among variables, ensuring robust and reliable results.

The study's sample size combined with a random sampling strategy and a validation survey of experts, provides a robust foundation for the study's analysis. This size is generally considered adequate for conducting Structural Equation Modeling (SEM) and ensures sufficient statistical power to detect relationships among variables. Although the use of convenience sampling could introduce some bias, the random elements incorporated in the sampling process help mitigate this risk, thereby enhancing the diversity and generalizability of the findings. Moreover, the expert validation adds an extra layer of credibility, reinforcing the practical applicability of the structural model. Overall, the sample size and methodology employed increase confidence in the reliability and validity of the study's results, supporting the statistical conclusions drawn from the data (Creswell and Creswell, 2018).

The reliability and validity of the data collection instruments were checked through EFA and reliability tests as presented in Table 3. The KMO measure of 0.812 and Bartlett's test of sphericity (significance level 0.001) ensured that the questionnaire was appropriate for factor analysis. All 25 variables had acceptable scores, above 0.6, by using Cronbach's alpha to check internal consistency. Composite Reliability further ensured that the data were strong (Hair et al., 2020). The results illustrate how there is possible strategic intervention to enhance ecological integrity and community wellbeing by incorporating public health and sustainability within the built environment. In the case of this research, all twenty-five variables returned high scores of reliability with a minimum threshold of Cronbach's alpha coefficient α of 0.6, hence presenting credible and consistent results. Cronbach & Shavelson, (2004); George and Mallery, (2003); state that scores of reliability falling within the ranges of 0.6–0.7 are considered acceptable. First, Cronbach's alpha helped ascertain the clarity and precision of the questionnaire tool. Further, by this testing procedure, the robustness of the obtained data is emphasized. This allowed the carrying out of a more valid and reliable survey instrument such that findings and conclusions from this study are credible.

The KMO measure of sampling adequacy was 0.812, which is acceptable according to the criteria of Cudeck, (2000), indicating that the questionnaire was appropriate for factor analysis. The latent constructs being analyzed were reliable since the Bartlett test of sphericity reached significance levels of 0.001. The threshold employed to assess the adequacy of factor analysis was 0.7. Besides testing the psychometric properties of the questionnaire, all demographic data from the 206 respondents were subjected to descriptive analysis. Participants' responses were rated on a scale based on five points, with the responses significant enough to reveal information about the study's goals.

TABLE 3 Reliability statistics of the questionnaire and the extracted factors.

Factors	Items' name	Cronbach's alpha (α)	No of items	Mean	Standard deviation (SD)
Sustainable Built Environment Practices (SBEP)					
A1	Waste and water management systems contribute to a sustainable built environment	0.853	7 items	5.889	1.858
A2	Green building technologies integrate to reduce environmental impact and promote sustainability				
A3	Urban green spaces play in enhancing sustainability and public health				
A4	Water quality management practices in urban areas contribute to a sustainable built environment				
A5	A degree in sustainable transportation systems (like biking, walking, and public transit) supports environmental sustainability				
A6	The status of COVID-19 pandemic mitigation and resilience strategies incorporated into urban planning are paramount				
A7	Integrating green infrastructure into urban planning supports sustainability and environmental resilience				
Public Health Risks (PHR)					
B1	The level of impact of poor water management on the spread of infectious diseases in urban environments	0.843	3 items	5.944	1.600
B2	Inadequate ventilation and poor indoor air quality in residential spaces affect public health				
B3	How does the lack of access to safe, secure housing conditions contribute to public health risks?				
Measurement Variables of Sustainable Urban Planning (SUP)					
C1	Accessible to green spaces in urban areas for physical and mental health benefits	0.877	5 items	5.378	1.755
C2	Sustainable infrastructure is integrated into urban planning to enhance public health and environmental sustainability				
C3	Urban planning promotes active transportation systems (cycling, walking) to enhance health and reduce pollution				
C4	Housing density regulations affect the spread of infectious diseases				
C5	Urban designs reduce heat island effects and improve public health outcomes				

(Continued on the following page)

TABLE 3 (*Continued*) Reliability statistics of the questionnaire and the extracted factors.

Factors	Items' name	Cronbach's alpha (α)	No of items	Mean	Standard deviation (SD)
Public health Improvement (PHIS)					
D1	The effectiveness of public health goals integration into urban planning strategies	0.735	5 items	5.811	1.588
D2	Robustness of the infrastructure manages public health emergencies in urban areas				
D3	Air quality improvement measures integration to protect public health				
D4	Accessible clean water and sanitation services improve urban populations' coordination				
D5	Accessible healthcare facilities and services improve urban residents' wellbeing				
Community resilience after COVID-19 (CRC)					
E1	Communities' involvement in urban planning decisions positively affects residents' resilience and health	0.781	5 items	4.668	1.959
E2	Public awareness campaigns promote resilience and health behaviours after COVID-19				
E3	Local social support systems aides recovery and resilience at the post-pandemic period				
E4	Economic initiatives support communities' financial stability and resilience after the pandemic				
E5	Well-preparedness of the community for adapting to future health crises based on lessons learned from COVID-19 are important				

6 Results

6.1 Demographic characteristics

In the case of gender, 53.9% are male with a total number of 111 out of the 206 respondents. On the other hand, 46.1% are female with a total of 95 out of the 206 respondents. This shows a fairly balanced set of genders in the case of this research study. The next largest groups were 36–45 years, at 25.2%, followed by 18–25 years with 17.9%, 46–55 years with 16.0%, and 56 years and above with 8.30%. Regarding educational background, the respondents had finished their undergraduate degree as the largest group, at 39.3%. The foregoing demographic profile gives a full description of the population of the respondents in terms of gender, age, education, occupation, income level, and experience in the profession (Figure 4). This diversified background ensures a wide array of perspectives on various research questions, including the rating of public health knowledge and sustainability awareness by the respondent; what the respondent thinks COVID-19 has influenced in terms of approaches to city planning and sustainability; how respondents perceive the relationship between public health and sustainable practices in the built environment; residents' perception of whether integrating considerations of public health into city planning can mitigate the impacts of future COVID-19 pandemics.

Figure 5 revealed a self-assessed knowledge about Public Health and Sustainability Awareness from 206 respondents, 50.97% described themselves as "Very familiar" with the topic and 41.75% of the respondents feel they are "Somewhat familiar." Only 7.28% said they were "Not familiar at all." This is a huge distribution in the sense that most of the respondents had awareness in the area of public health and sustainability falling within the range of a little to average. These findings show that most respondents have at least a moderate understanding of public health and sustainability issues. In fact, over half (50.97%) consider themselves "Very familiar," while an additional 41.75% describe themselves

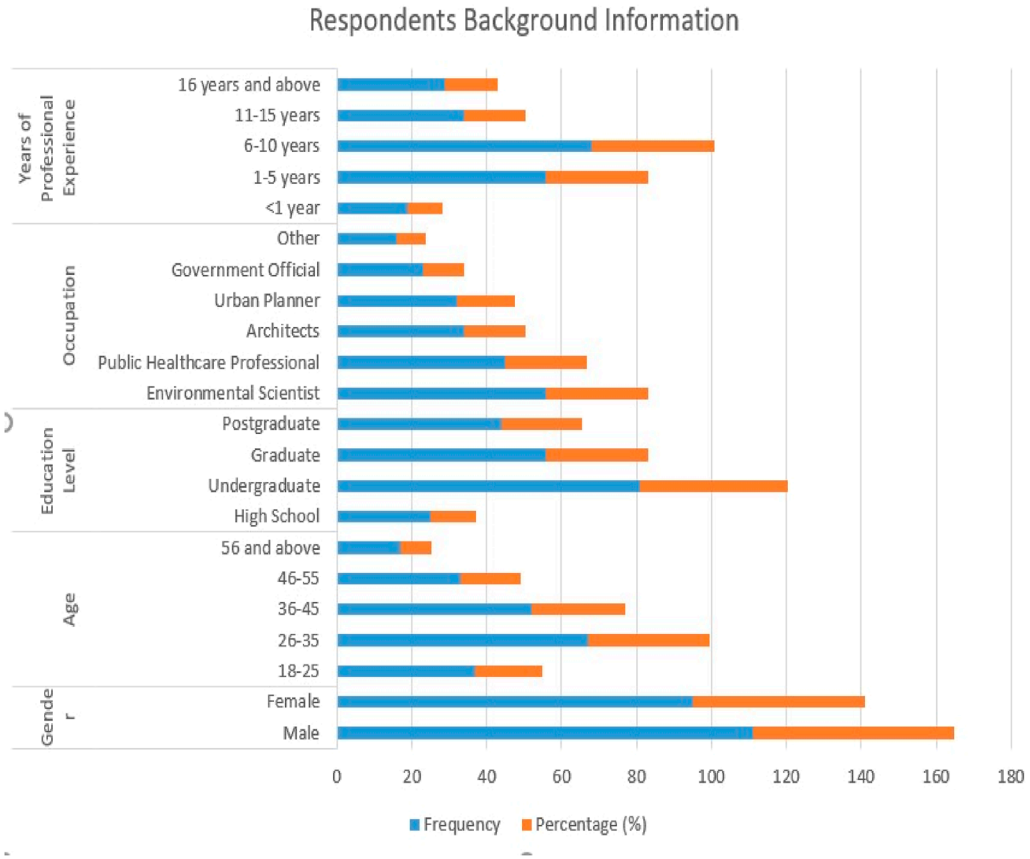

FIGURE 4
Respondents' background information.

as "Somewhat familiar." Only a small percentage (7.28%) report being completely unaware. This distribution points to a generally high level of engagement and foundational knowledge among participants, which could help in adopting sustainability-focused policies and public health measures. As a result, policymakers and urban planners may find a conducive environment for implementing initiatives, given that many stakeholders already appreciate the significance of these concepts. However, the presence of respondents who are "Not familiar at all" highlights the need for ongoing education and outreach efforts to ensure that all community members can effectively engage with or benefit from health- and sustainability-related strategies.

Figure 6 presents the ratings from the respondents on the extent to which those variables influence public health and sustainability. The diagram shows that a large number of respondents believe COVID-19 has had a significant impact on urban planning and sustainability strategies, as indicated by the high numbers in the "High extent" and "Very high extent" categories. This implies that many professionals and stakeholders see the pandemic as a trigger for rethinking urban design, focusing on health, resilience, and adaptability. On the other hand, the relatively lower numbers for "No extent" and "Low extent" suggest that only a small portion perceives little or no impact. Thus, this highlights an increasing awareness that public health crises can influence changes in resource allocation, building design, and policy frameworks, potentially fostering more sustainable and resilient urban environments. As a result, policymakers and urban planners may need to integrate lessons learned from COVID-19 into their long-term strategies, ensuring that future developments prioritize community wellbeing and ecological balance.

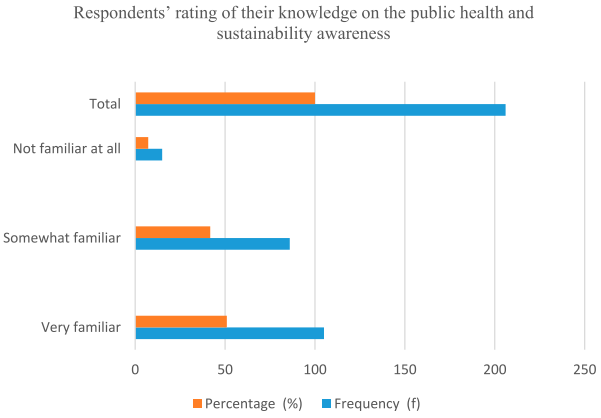

FIGURE 5
Respondents' rating of their knowledge of the Public Health and Sustainability Awareness.

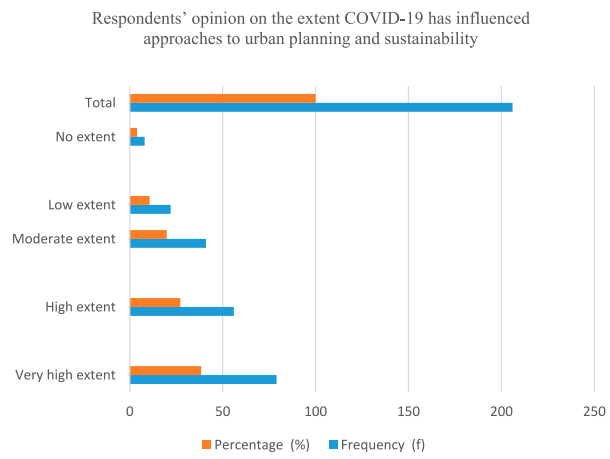

FIGURE 6
Respondents' opinion on the extent COVID-19 has influenced approaches to city planning and sustainability.

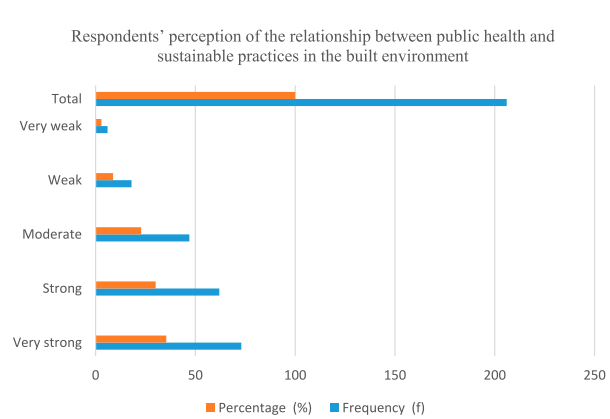

FIGURE 7
Respondent's perception of the relationship between public health and sustainable practices in the built environment.

Figure 7 summarizes respondents' perceptions of the strength of certain factors influencing public health and sustainability. It indicates that a significant number of respondents see a strong or very strong connection between public health and sustainable practices in the built environment, as shown by the high frequencies in these categories. This suggests a widespread agreement that sustainable design, resource efficiency, and eco-friendly construction methods are crucial for protecting community health. Conversely, a smaller number of respondents express weak or very weak opinions on this relationship, indicating that only a few remain unconvinced of the link. This suggests that professionals and stakeholders largely acknowledge the need to integrate public health considerations into sustainable building strategies. As a result, policymakers and urban planners may be encouraged to include health-oriented measures such as better ventilation, green spaces, and reduced pollution in future construction and planning guidelines, ultimately improving both environmental quality and wellbeing in urban areas.

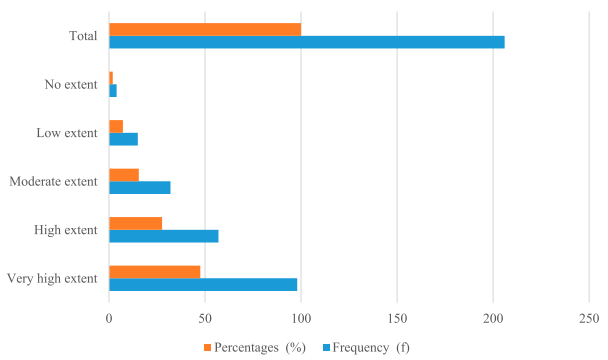

FIGURE 8
Residents' perception of the integration of public health considerations into city planning can mitigate the impacts of future COVID-19 pandemics.

Figure 8 shows the extent to which the respondents rate selected factors as impacting public health and sustainability. It illustrates that a significant portion of respondents believe that incorporating public health considerations into urban planning can significantly reduce the effects of future COVID-19 pandemics, as shown by the high numbers in the "High extent" and "Very high extent" categories. In contrast, only a small number of respondents selected "No extent" or "Low extent," indicating that there is minimal scepticism regarding the impact of health-focused urban planning. Findings suggest a strong agreement that initiatives like improved ventilation, accessible healthcare facilities, and flexible public spaces are essential for boosting resilience against pandemics. As a result, policymakers and city planners may be motivated to implement and institutionalize health-oriented strategies within their urban development plans to better protect communities from future health emergencies.

6.2 Measurement model results

The Kaiser-Meyer-Olkin (KMO) value was 0.852, indicating excellent sampling adequacy for Principal Component Analysis (PCA). Additionally, Bartlett's test of sphericity was highly significant ($p < 0.05$, value = 0.000), confirming that the dataset was suitable for PCA. This confirms that the data was suitable for PCA, with 85% of the data being deemed appropriate for factor analysis. The application of EFA was adopted to assess the strategic city planning model for sustainable health and safety in the post-pandemic era. The results of PCA, as shown in Table 4, identified and classified variables into major components. The assessment of 25 variables after five cycles resulted in five primary components of the highest convergence. The iterations, with variance percentages of 17.90%, 17.79%, 16.46%, 16.40%, and 15.59% respectively, account for 84.14% of the total variation. These percentages thus indicate that these five factors combined accounted for 77.14% of the total variation in the original data. The varimax rotation as recommended by Pallant (2020) resulted in the rotated element structure shown here, while five of the factors had eigenvalues greater than 1.

TABLE 4 Construct of a rotated matrix in EFA.

Item code	Sustainable built environment practices (SBEP)	Public health risk (PHR)	Sustainable urban planning (SUP)	Public health improvement strategies (PHIS)	Community resilience after COVID-19 (CRP)
SBEP1	0.895				
SBEP2	0.842				
SBEP3	0.831				
SBEP4	0.809				
SBEP5	0.832				
SBEP6	0.858				
SBEP7	0.838				
PHB1		0.782			
PHB2		0.792			
PHB3		0.711			
SUP1			0.790		
SUP2			0.735		
SUP3			0.706		
SUP4			0.719		
SUP5			0.792		
PHIS1				0.588	
PHIS2				0.599	
PHIS3				0.531	
PHIS4				0.589	
PHIS5				0.728	
CRP1					0.600
CRP2					0.522
CRP3					0.511
CRP4					0.598
CRP5					0.531
%Variance explained	16.90%	14.79%	14.46%	14.40%	16.59%

6.3 Model of confirmatory factor analysis (CFA)

To see whether the framework has determined that various factors in an assessment are reasonable and correct, we have performed CFA. This is proposed to improve the quality of CFA, which excludes observed variables from the model with a lower threshold than 0.6 (Baharum, et al., 2023). Figure 9 represents the measurement model of the factors relating to the built environment sustainability in tandem with post-COVID-19. Reliability and validity of the Structural model in Table 5 present all the CR values to be greater than 0.8, which shows acceptable levels of validity (Cheah, et al., 2018). GOF indices for the structural model in Table 6 are all within acceptable ranges, indicating that the CFA model fits well (Sahoo, 2019). Based on the results from CFA, a framework of the structural model

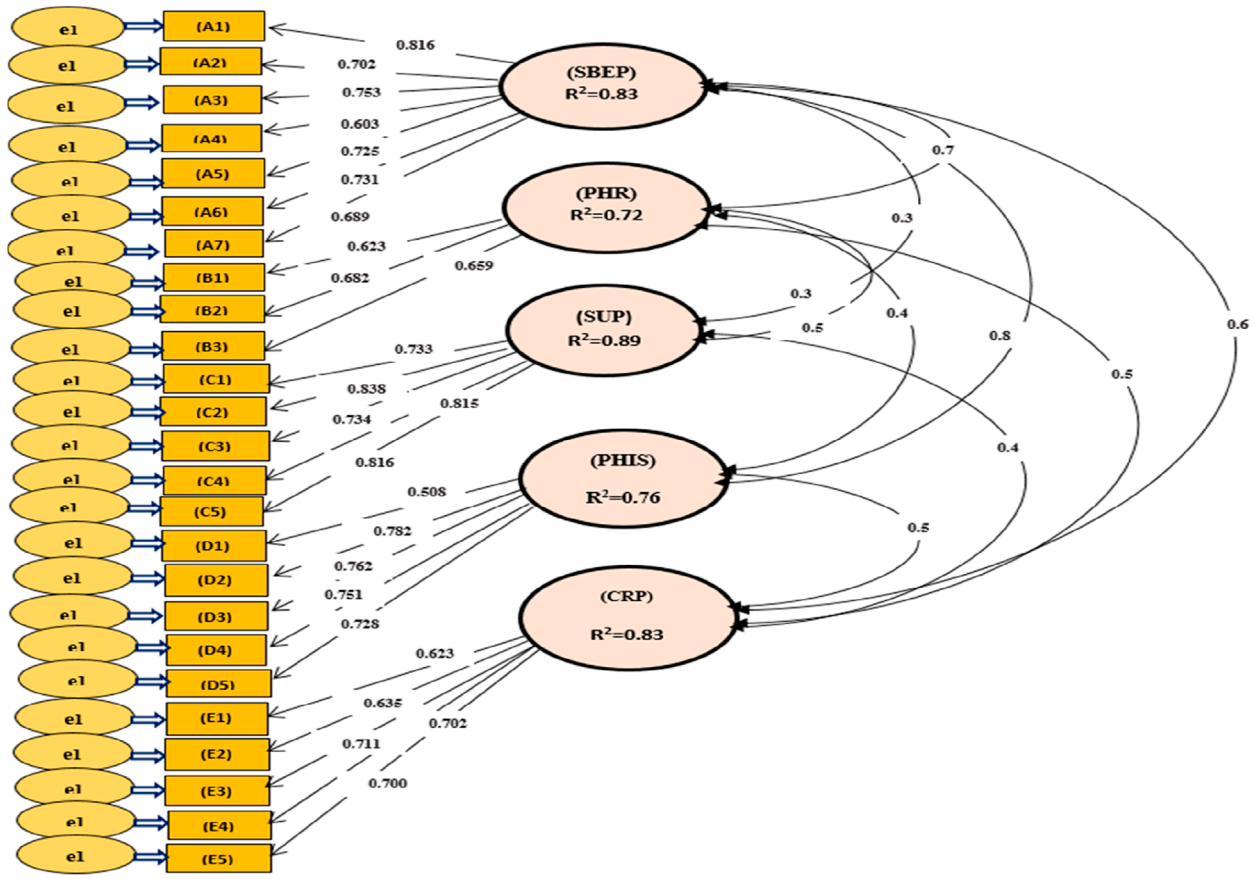

FIGURE 9
Measurement model of the constructs.

TABLE 5 Reliability and validity of the Structural model.

	CR	AVE	MSV	MaxR (H)	SBEP	PHR	SUP	PHIS	CRP
SBEP-Sustainable Built Environment Practices	0.961	0.696	0.455	0.951	**0.822**				
PHR-Public Health Risk	0.952	0.611	0.435	0.954	0.700	**0.721**			
SUP -Sustainable Urban Planning	0.818	0.845	0.410	0.823	0.535	0.128	**0.761**		
PHIS-Public Health Improvement Strategies	0.920	0.711	0.388	0.969	0.699	0.270	0.040	**0.885**	
CRP-Community Resilience Post COVID-19	0.981	0.823	0.396	0.855	0.622	0.222	0.161	0.302	**0.749**

The bold values represent the square root of the Average Variance Extracted (AVE) for each construct.

was built as illustrated in Figure 10. The framework contains five sub-groups and nineteen factors that form the main results of this study.

6.4 Results of the tested hypotheses

Figure 10 shows the path analysis outcomes for the four path analysis constructs derived from the structural model revealing how Community Resilience post-COVID-19 pandemic (CRP) indices are indirectly influenced by constructs such as Sustainable Built Environment Practices (SBEP), Public Health Risk (PHR), Sustainable Urban Planning (SUP), and Public Health Improvement Strategies (PHIS). Table 7, presents the results altogether showing the importance of sustainable urban planning to community resilience in the post-pandemic era. These findings are also in tandem with the current debate on the need for embedding sustainability into urban planning as part of the effort toward health and safety. The following summarizes the key findings of each hypothesis.

TABLE 6 Goodness of Fit indices for the Structural model.

Index	Indices achieved
RMSEA	0.085
GFI	0.936
CFI	0.940
TLI	0.936
Cmin/df	2.086
ChiSq	262.372

(i) Hypothesis H1: Sustainable Urban Planning Practices and Community Resilience

The results obtained show a positive relationship between sustainable urban planning practices and increased community resilience post-COVID-19. With a path coefficient of 0.659 and a p-value of 0.004, the results strongly indicate that the adoption of sustainable planning practices significantly positively influences community resilience. This finding underlines the need to incorporate responses of sustainable architecture and design within the built environment to reduce the long-term effects of the pandemic. Integration of green infrastructure, efficient land-use policies, and resilient urban designs become a cornerstone in fostering post-pandemic recovery. These findings are in line with previous studies on the identification of the psychological and physiological benefits linked with green spaces, including reduced stress and increased physical activity. Research work has revealed that integrating health objectives into urban planning strategies contributes to the reduction of pollution and enables active lifestyles promoting sustainable and resilient urban environments.

(ii) Hypothesis H2: Community Resilience could be achieved through Reduced Public Health Risk

Public health risk reduction significantly contributes to increasing community life resilience in urban areas during the post-pandemic period, based on the path coefficient of 0.830 and p-value of 0.002. This strong positive relationship would mean that the integration of green technologies, such as air quality improvement systems, green materials, and renewable energy solutions, would positively contribute to health improvement. This approach also complies with the objectives of sustainable urban development at an international level and illustrates how the mitigation of health risks would increase the resilience of an urban community to multiple challenges in the future. Findings signify that the fight against COVID-19 also requires investments in urban infrastructure to ensure public health.

(iii) Hypothesis H3: Sustainable Urban Design Practices and Community Resilience

This hypothesis is further asserted by a path coefficient of 0.750 and a significant p-value of 0.003, which further implies that sustainable urban design practices are critical in ameliorating the impacts of the post-COVID-19 era. The findings thus indicate that not only does good urban design bring out the aesthetic and functional value of cities but also that it significantly contributes to community resilience. It is policies of walkable space, and resource access equity that drive this impact.

(iv) Hypothesis H4: Improvement in Public Health Strategies and Challenges of Throwing COVID-19

Public Health Improvement Strategies were found to have a large influence on the challenges mentioned above due to post-COVID-19. This hypothesis is very strongly verified because the path coefficient is 0.640, and the significant level is 0.001. These findings further underline the need for focused health interventions through community health programs, strong healthcare infrastructure, and public awareness campaigns toward improved health outcomes and resilience-building to future shocks. Table 8 further elucidates the total effect coefficients and shows that SBEP directly influences 0.065 on post-COVID-19 pandemic indices, 0.044 on PHR, 0.159 on SUP, and 0.042 on PHIS. Notably, the highest overall effect on post-COVID-19 indices is contributed by Sustainable Urban Planning, as reflected in the effect size of 0.159. These confirm the prime importance of sustainable planning practices in the making of resilient urban environments.

7 Discussion

7.1 Sustainable cities' planning and its contribution to improving public health outcomes

This study highlights the pivotal role of sustainable city planning in enhancing public health, especially post-COVID-19. The implications of these results are multifaceted and significant for sustainable urban development. First, the positive relationship between sustainable built environment practices and reduced public health risks confirms that integrating health objectives into urban planning can lead to tangible improvements in community resilience and environmental quality (Lee, et al., 2022; Sallis, et al., 2021; Capolongo, et al., 2020). This suggests that policymakers should prioritize green building practices, efficient waste and water management, and renewable energy adoption as core elements of urban design to mitigate health risks, especially in the post-COVID-19 era.

Sustainable practices like green building, efficient waste and water management, and renewable energy adoption mitigate health risks and boost environmental resilience. Research supports that such strategies reduce the adverse effects of pollution and waterborne diseases while improving public health. Key findings emphasize city green spaces and community engagement as vital for fostering resilience and mitigating health risks. These insights are supported by the studies of Anderson et al. (2021) and Chmitorz, et al. (2018); who highlighted green infrastructure's role in promoting physical and mental wellbeing and regulating city temperature and air quality. These findings underscore the importance of integrating sustainable design into city environments for healthier, more resilient communities.

This study emphasises water and waste management systems reduce waterborne diseases and pollution-related health issues,

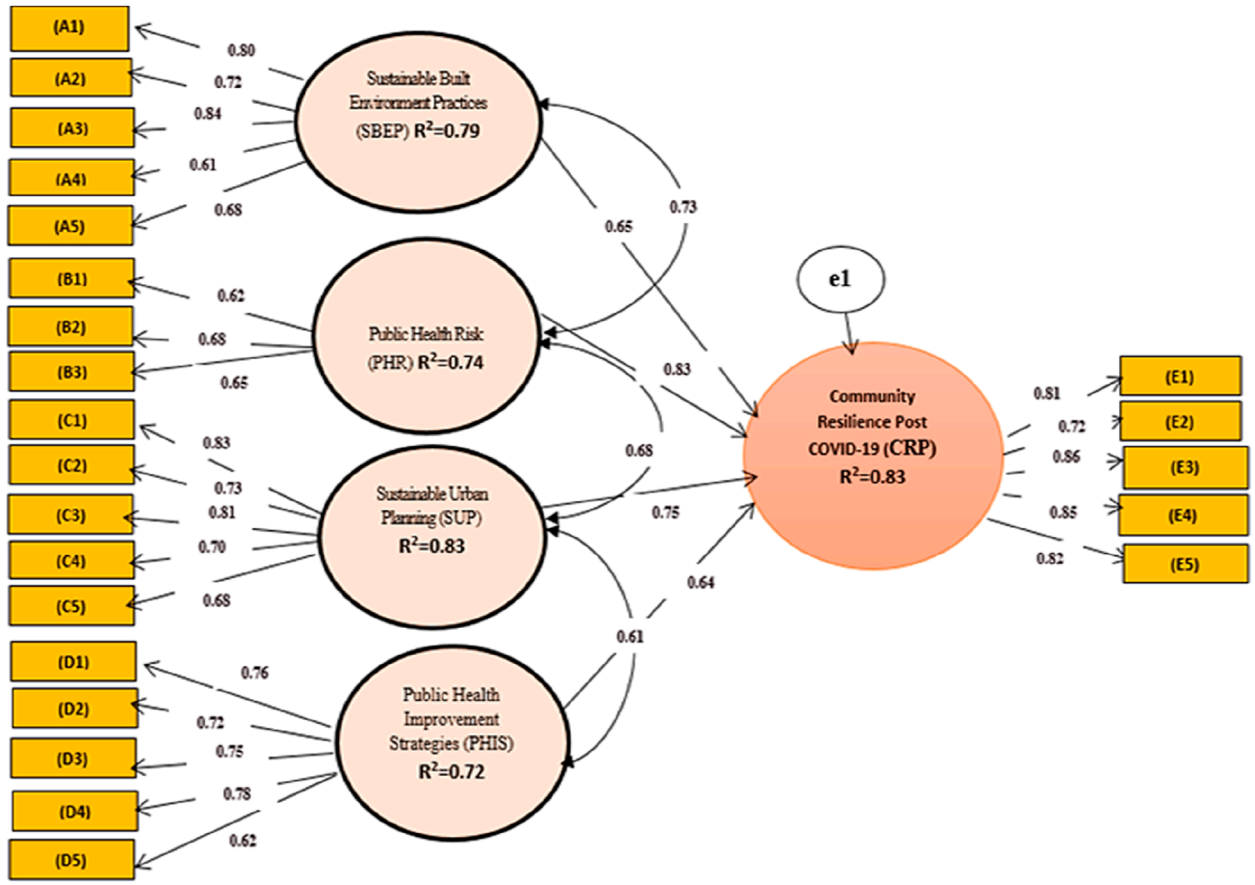

FIGURE 10
Final structural model of the construct.

TABLE 7 Results of the structural path model.

Relationships	Path coefficients	Significant (P) values	Test result
H1: Sustainable Built Environment Practices → Community Resilience after COVID-19	0.650	0.004	Supported
H2: Public Health Risk → Community Resilience after COVID-19	0.830	0.002	Supported
H3: Sustainable Urban Planning → Community Resilience after COVID-19	0.750	0.003	Supported
H4: Public Health Improvement Strategies → Community Resilience after COVID-19	0.640	0.001	Supported

Note:***<0.001,** <0.01.

TABLE 8 Results of the total effect coefficients.

Path	Indirect effect	Direct effect	Total effect
H1: Sustainable Built Environment Practices→ Community Resilience after COVID-19	0.000	0.065	0.065
H2: Public Health Risk → Community Resilience after COVID-19	0.000	0.044	0.044
H3:Sustainable Urban Planning → Community Resilience after COVID-19	0.000	0.159	0.159
H4: Public Health Improvement Strategies → Community Resilience after COVID-19	0.000	0.042	0.042

reinforcing the importance of environmental sustainability. Holistic city planning strategies must prioritize public health alongside sustainability, addressing vulnerabilities from pandemics. Green spaces, vital for reducing pollution, and improving public health, are key to city design to manage the post-COVID-19 disaster in the future. This is in tandem with the previous research by Al-Ansari, & Al-Khafaji, (2023). In addition, by providing shade, and supporting health-promoting activities, city development could prioritize human needs by enhancing walkability, cycling, and green infrastructure. The findings observed in this study align with those of the previous studies that have examined city design with the principles foster a sustainable and human-centred environment. Future planning must integrate these approaches to ensure environmental sustainability and public wellness remain paramount concerns.

City surroundings significantly influence health, wellbeing, and disparities, with urban areas particularly vulnerable to shocks like pandemics and environmental degradation. This is corroborated by Elmqvist et al. (2013) by highlighting that cities generate waste and greenhouse gas emissions which call for prioritizing residents' health in the city crucial. This study revealed that urban strategies integrating infrastructure have been shown to improve health, as supported by Van der Waal, & Thijssens, (2020) and Güler, & Aykaç, (2020). Efficient systems are vital in preventing diseases in densely populated areas. The intersection of architecture, city planning, and public health is essential for building disaster-resilient communities. This research underscores the urgent need for integrated urban policies that balance public health and sustainability to combat threats from infectious diseases and associated environmental challenges.

7.2 Adaptive strategies for improving the built environment to address the post-era COVID-19 epidemic

This study highlights strategies for improving the built environment in reaction to the COVID-19 epidemic, with important ramifications for the design and planning of cities. The empirical evidence supporting the integration of public health goals into city planning further underscores the need for a holistic approach. The statistically significant improvements observed in environmental sustainability and community resilience indicate that when aligned with public health strategies, adaptive urban service models can effectively reduce vulnerabilities and enhance overall urban wellbeing (Capolongo, et al., 2020). These results are consistent with those of Conway, et al. (2023) by suggesting that reducing the post-COVID-19 pandemic and its vulnerabilities could improve public health systems and community resilience. Adaptive strategies are essential for creating sustainable, health-focused, and resilient environments. This includes flexible designs for public spaces, and transportation systems and improved air circulation while ensuring long-term sustainability. The integration of green infrastructure, renewable energy, and efficient waste management systems is critical to reducing environmental health risks; as these findings further support the idea of Wang, et al. (2020); and Afolabi, & Adedire, (2023). These strategies align with the broader movement toward sustainable city development, emphasizing the need to embed public health priorities into planning processes. Such efforts address public health challenges while combating disease risks as corroborated by the studies of Bageis, et al. (2023); and Bakir, (2020).

Strategic urban planning in the post-COVID-19 pandemic era helps integrate emerging priorities into city plans, programs, or governance arrangements, but must also consider political and economic interests for equitable development. These strategies include fostering strategic citizen involvement; environmental consciousness, and maximizing operational green spaces as the finding confirms the previous studies by Agboola, et al. (2024); Ergin, & Türkmen, (2021); and Wamsler, et al. (2013). These measures are deemed essential for addressing the impacts of the post-COVID-19 pandemic. This approach recognizes the interconnectedness of human actions and their impacts on the environment, emphasizing the importance of individual and collective responsibility in addressing post-COVID-19 challenges. These results match those observed in earlier studies by Watson, et al. (2020) and Kadykalo, et al. (2022); that fostering environmental consciousness is a vital strategy for combating post-COVID-19; as it empowers individuals, communities, businesses, and institutions to take proactive steps toward building a more sustainable and resilient future. By raising awareness, promoting behavioural change, advocating for policy action, engaging stakeholders, and enhancing community resilience, and environmental consciousness.

Global organizations like UN-Habitat and the WHO stress the need to strengthen connections between city design and public health in response to the COVID-19 pandemic; highlighted by the WHO (2022) that city planning's potential could improve health outcomes and address inequities by reshaping spatial functions. Similarly, advocate for a people-centred approach that integrates public health into city planning, fostering resilient, equitable, and sustainable environments. These emphasize that sustainable city design, prioritizing green spaces and community engagement, enhances social cohesion and wellbeing during crises. This aligns with findings by the studies of Öztürk, (2021) and Barton, & Grant, (2006), on city strategies that improve mental health outcomes by incorporating accessible green spaces.

8 Conclusion

This study significantly contributes to adaptive strategies aimed at enhancing the built environment in response to the COVID-19 pandemic in Turkey. By aligning with global frameworks like the United Nations Sustainable Development Goals (SDGs) especially SDG 11, which focuses on Sustainable Cities and Communities it underscores the importance of developing urban spaces that are inclusive, safe, resilient, and sustainable. SDG 11 highlights the need for improved city planning and management to promote sustainable development while tackling urgent challenges, including public health risks. In this context, the study provides practical insights by identifying strategies to incorporate sustainability principles into urban design and disaster risk management. These approaches not only address immediate health concerns but also prepare urban areas to face future crises, thereby fostering adaptive and resilient urban systems. By prioritizing inclusive and resilient planning, local authorities and stakeholders can better inform, support, and protect citizens, ultimately aligning with broader global sustainability goals.

A key theme of the research is the shift towards a regenerative paradigm in transforming the built environment, which is crucial for alleviating the ongoing effects of COVID-19 in urban settings. The study's originality lies in its empirical analysis of the factors affecting both sustainable built environments and public health risks in the post-COVID-19 landscape. The findings highlight the effectiveness of various interventions spanning technological innovations, city planning strategies, and public awareness campaigns in enhancing environmental sustainability and urban resilience in Turkey. By promoting the integration of green infrastructure and sustainable building practices, the study presents a comprehensive framework that connects climate adaptation with urban planning.

This synthesis is especially crucial for communities dealing with complex challenges, as it ensures that environmental goals and public health priorities support one another. Additionally, the study underscores the essential role of technology in global efforts toward environmental sustainability. Investing in and adopting new technologies can improve resilience and reduce the effects of pandemics on at-risk urban populations. As technological advancements in efficiency and sustainability progress, they become more integrated into global initiatives aimed at protecting cities from future health and environmental risks. This research highlights the importance of combined adaptation strategies that incorporate health and post-COVID-19 considerations into urban development, aligning with the UN's post-2015 agenda to foster social, economic, and sustainable growth. Ultimately, by addressing the unique vulnerabilities of urban areas in the aftermath of health crises, the study offers a blueprint for creating cities that not only address immediate public health needs but also promote long-term resilience and sustainability for future generations.

Sustainable city planning is essential for enhancing public health outcomes, a reality that has become increasingly clear in the aftermath of COVID-19. The study emphasizes that incorporating sustainability into urban design can help reduce health risks and strengthen environmental resilience. For instance, green building practices not only lower energy use but also enhance indoor air quality, which directly leads to healthier living environments. Effective waste and water management systems help decrease pollution and limit the spread of waterborne illnesses, while the use of renewable energy sources reduces carbon emissions and promotes cleaner air. In addition, sustainable city planning promotes the development of green spaces and recreational areas, which encourage physical activity, alleviate stress, and strengthen community ties. These factors together lead to better mental and physical health for urban dwellers. By aligning urban development with sustainable practices, policymakers and urban planners can create spaces that are not only resilient to future pandemics but also supportive of long-term public health. Ultimately, sustainable city planning addresses current environmental issues while laying the groundwork for healthier, more adaptable communities.

Strategies for enhancing the built environment in the post-COVID-19 era are crucial for developing resilient and healthy urban spaces. The findings of the study highlight that the integration of smart technologies, sustainable design practices, and public health goals can revolutionize urban planning. For example, the research showed that adaptive measures like the inclusion of green infrastructure, improved natural ventilation, and the creation of flexible public spaces can greatly reduce health risks linked to pandemics. These strategies not only boost energy efficiency and environmental sustainability but also strengthen community resilience by encouraging social cohesion and better public health outcomes. As cities rethink their design frameworks, these adaptive strategies offer a guide for harmonizing modern technological solutions with traditional urban planning principles. The implications are significant as city planners and policymakers can leverage these insights to redesign urban areas that are not only responsive to immediate health challenges but also sustainable in the long run, ultimately fostering environments that promote both ecological integrity and human wellbeing.

8.1 Policy implications

The study highlights practical implications for policy and urban planning, addressing the existing research gap while providing evidence-based recommendations for enhancing public health through sustainable design practices. Also, the role of policymakers, educators, employers, and researchers in raising COVID-19 awareness through public campaigns could not be underrated. The campaigns enhance understanding of the relationship between health and the built environment, focusing on preventive measures, sustainable behaviours, and the adoption of renewable energy and green infrastructure. They foster community responsibility, encouraging resilience and policy changes for healthier city centres. These initiatives address immediate COVID-19 impacts and prepare communities for future health crises, promoting sustainability and resilience. The findings provide critical insights for city planners and policymakers striving to create safer, healthier, and more sustainable cities, ensuring long-term ecological and social benefits for city environments.

These findings advocate for a comprehensive policy framework that not only addresses immediate public health concerns but also builds long-term adaptive capacity in urban environments. This integrated approach can guide urban planners and local governments in designing cities that are both resilient to future crises and conducive to sustainable development for all residents. Effective adaptation strategies in cities should be multi-layered, from structure-oriented approaches such as using sustainable infrastructure to socio-oriented approaches like public health campaigns and community involvement. This pandemic underlines even further the imperative for resilient city design, considering both immediate and long-term threats. Given the response of Turkey during this pandemic and the general approach to city planning, the current study offers very important lessons for policymakers and city planners from around the world. It promotes the integration of health, safety, and environmental sustainability into city planning frameworks to construct healthier, safer, and more resilient cities that can prevail over pandemics. Public awareness creates healthy, safe, and sustainable built environments through education and community participation. As such, nexus relationships between environmental change and city landscape warrant adequate attention from experts, governments, and non-government agencies.

Summarily, In Istanbul, the application of these policy recommendation strategies requires collaboration between the

government, private developers, and communities. Policymakers must integrate sustainable urban planning by prioritizing green infrastructure, mixed-use developments, and resilient public spaces that support both health and environmental sustainability. Private developers should adopt eco-friendly construction methods, invest in renewable energy, and incorporate walkable urban designs, aligning projects with long-term sustainability goals. Community involvement is crucial, with public awareness campaigns fostering responsible urban behaviours, promoting green lifestyles, and enhancing pandemic preparedness. A multi-layered policy framework will ensure Istanbul remains adaptable, balancing ecological integrity with public wellbeing for a more resilient future.

8.2 Research limitation and future perspective

In connection with the study's limitation; the study focuses on city environments, potentially neglecting the interplay between city and rural areas in built environment adaptations. While the study identifies and examines several key factors influencing sustainable built environment and public health rısks in the wake of the COVID-19 pandemic, it may not cover all possible predictors. Other relevant variables that could influence the built environment's response to environmental issues might be considered in the future study. This study's sampling strategy, which includes both random and convenience sampling, has some potential drawbacks. For example, random sampling can be time-consuming, labour-intensive, and costly, particularly when dealing with large populations. Additionally, convenience sampling might lead to systematic bias since participants are selected based on their availability. To mitigate the limitations of random sampling, the study improves response rates by implementing follow-ups, offering incentives, and utilizing various contact methods. Furthermore, the researcher promotes accessibility and inclusivity by employing multiple channels for participant recruitment. By integrating these two sampling methods and applying strategies to reduce bias, the study seeks to enhance the reliability and relevance of its findings.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the (patients/ participants OR patients/participants legal guardian/next of kin) was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

OA: Conceptualization, Writing – original draft, Writing – review and editing, Data curation, Methodology, Software, Formal Analysis, Validation, Visualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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