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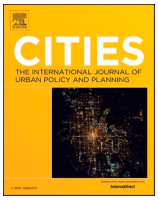

Respiratory pandemics, urban planning and design: A multidisciplinary rapid review of the literature

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ABSTRACT

COVID-19 is the most recent respiratory pandemic to necessitate better knowledge about city planning and design. The complex connections between cities and pandemics, however challenge traditional approaches to reviewing literature. In this article we adopted a rapid review methodology. We review the historical literature on respiratory pandemics and their documented connections to urban planning and design (both broadly defined as being concerned with cities as complex systems). Our systematic search across multidisciplinary databases returned a total of 1323 sources, with 92 articles included in the final review. Findings showed that the literature represents the multi-scalar nature of cities and pandemics – pandemics are global phenomena spread through an interconnected world, but require regional, city, local and individual responses. We characterise the literature under ten themes: scale (global to local); built environment; governance; modelling; non-pharmaceutical interventions; socioeconomic factors; system preparedness; system responses; underserved and vulnerable populations; and future-proofing urban planning and design. We conclude that the historical literature captures how city planning and design intersects with a public health response to respiratory pandemics. Our thematic framework provides parameters for future research and policy responses to the varied connections between cities and respiratory pandemics.

1. Introduction

Cities, urbanisation and urban living have been fundamental to the spread of respiratory pandemics such as COVID-19. Indeed, such pandemic infections have shaped the course of human history (Norwegian Institute of Public Health, 2020). Urban settings are at the epicentre

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of COVID-19 and require public health and social policy measures, known as non-pharmaceutical interventions (NPIs), to restrict transmission (World Health Organisation, 2019). NPIs range from personal protective, environmental measures, social distancing, and travel-related measures (World Health Organisation, 2019).

Urban planning and design had roots in 19th-century public health pandemics but have evolved as distinct sectors and disciplines. In the past 15 years, a resurgent literature and policy orientation toward 'healthy urban planning' has come largely through a concern with preventing non-communicable diseases or chronic conditions. As a result, communicable diseases such as respiratory pandemics have tended to take a back seat in this latest body of knowledge (Norwegian Institute of Public Health, 2020).

An extensive evidence base supports the links between urban planning and design with healthy behaviours, traffic injuries, noise, air quality, and access to jobs, food and services, as well as the creation or exacerbation of spatial health inequities (for evidence reviews, see e.g. Ige-Elegbede et al., 2020; Giles-Corti et al., 2016). These 'health' dimensions are closely aligned with aspects of neotraditional planning (new urbanism and smart growth) dating back to the 1990s. 'Healthy urban planning' as it has come to be known, aims to integrate these various dimensions of public health into planning policy and practice. For instance the World Health Organisation recently produced an authoritative sourcebook for integrating health and wellbeing in planning covering: environmental measures including sanitation and injury prevention; healthy lifestyles such as food and physical activity; and 'ecology' which enables health and wellbeing through sustainable energy, bio-diversity and local resilience (World Health Organisation, 2020). Focussing explicitly on COVID-19 and cities, recent literature has focussed on and modern lifestyles interacting with environmental, socioeconomic, transport factors, necessitating resilient local city planning systems and governance (Sharifi & Khavarian-Garmsir, 2020).

Given what we know about cities and their functioning, conceptualising the relationship between urban planning and design and pandemics is essential. Pandemics throw core concepts about cities into sharp relief, such as city-regions and urban scale approaches (Scott & Storper, 2015). COVID-19 has clearly shown the importance of urban areas in the spread within and between cities and city regions both globally and within countries (Cave et al., 2020). From a multi-scalar urban perspective (Brenner, 2019), COVID-19 was first confirmed in cases linked to a wet market in Wuhan, China, spreading person to person through city networks and profoundly impacting localities, neighbourhoods, homes, families, networks and individual lives. Pandemics like COVID-19 also cut across principles of urban design that go beyond aesthetics to embrace amenity, accessibility, community, vitality and sustainability and which necessarily cross into urban politics and governance (Punter, 2007).

NPIs and other public health measures appear to effectively prevent the spread of the disease (Cochrane Library, 2021). However, there are profound social and economic consequences to implementing such measures in localities, cities and across the globe (Haug et al., 2020). Such inequities require attention to the structural determinants of health (Paremoer et al., 2021). Urban studies and theory would suggest that cities and urban governance behind the functioning of cities are crucial structural factors in preparing for and responding to respiratory pandemics (Storper & Scott, 2016). The complex connections between public health and pandemics emphasise the need for multidisciplinary knowledge generation and policy responses (Norwegian Institute of Public Health, 2020).

Despite the apparent conceptual connection between NPIs and urban planning and design, there are few literature reviews on this topic. The type of complexity involved in urban planning and design NPIs into pandemics challenges traditional systematic review approaches. For example, a Cochrane review of physical interventions to reduce the spread of respiratory viruses demonstrates the challenges of fitting such broad concepts into a systematic review (Jefferson et al., 2008). Physical barriers such as handwashing, wearing a mask, and isolation of potentially infected people were reviewed as effective in preventing the spread of respiratory viruses. Social policy initiatives such as border closures and social distancing, school closures and bans on public gatherings were unable to be evaluated for effectiveness. Urban planning and design were not considered.

A less stringent approach to reviewing the literature is necessary. Rapid reviews are a type of knowledge synthesis in which components of the systematic review process are simplified or omitted to produce information in a short period with a focus on quick decision making in policy contexts (Khangura et al., 2012). The elastic nature of rapid reviews is in response to resources, timeframes and decision-making processes, rather than the quantity and quality of the available evidence (Haby et al., 2016). For this reason, when compared to traditional systematic reviews, there is far more scope for heterogeneity in why and how rapid reviews are employed.

The rapid review sought to answer the following question:

What multidisciplinary literature has been published analysing efforts to use urban planning and design policies and practices to mitigate the health and equity problems caused by pandemics of respiratory disease in cities?

The rapid review addressed this research question through an examination of multi-disciplinary literature on how planning and designing cities intersects with pandemics of infectious respiratory diseases spread by droplets, specifically SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), SARS-CoV, MERS -CoV (Middle East respiratory syndrome coronavirus) and influenza viruses.

2. Material and methods

2.1. Search terms and inclusion and exclusion criteria

Search terms were developed in several steps. First, each author reflected between 15 min and 1 h for their particular interests in the connections between pandemics (specifically COVID-19) and urban planning and design. These discussions revealed a broad brush of issues, including urban planning, built environment, building design, housing, governance and equity. Second, a pilot search for similar specific terms in the database 'Proquest' showed that these terms tended to limit the available literature to small numbers and reduce our scope. It was subsequently agreed to apply broad categories to cover our main inclusion criterion to focus on respiratory pandemics and excluding other types of pandemics: 'pandemic OR coronavirus' AND 'urban OR city' AND 'planning OR design' NOT 'AIDS or cholera OR plague OR HIV OR obesity'.

The full structured search for published literature was conducted across multidisciplinary databases: Proquest, EbscoHost, Medline, Scopus, and Web of Science. The timeframe for inclusion was the 20th century onwards. An additional search was conducted on google scholar. This study was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (Liberati et al., 2009).

2.2. Identification and selection of studies

We reviewed the full body of English only papers – for rapid review purposes – against the inclusion and exclusion criteria (Box 1).

The screening was conducted using Zotero in a two-stage process. During the first stage, the title and abstract for each study were reviewed. In the first round, studies classified as 'yes' or 'maybe' moved through to the next stage (full-text screening). In this stage, reviewers (all authors of this paper) were allocated papers that potentially connected to their interests and areas of expertise. Next, each reviewer reviewed the full text for each citation. Next, a comprehensive, fit-for-purpose data extraction template was designed and piloted by the research team. Finally, each reviewer completed the data extraction database for the final included sample.

Box 1
Inclusion and exclusion criteria.

Inclusion criteria
Language: English only
Context: Urbanised contexts associated with pandemics of respiratory disease; global and regional networks or sites relevant to cities such as shipping and transport networks, ports and airports.
Publication time frame: From 1918 (Spanish Flu)
Publication status: Material published in peer reviewed journals or book chapters
Subject focus: Regional and local urban planning and design responses to pandemics of infectious respiratory diseases (either coronaviruses or influenza pandemics or both), specifically SARS-CoV-2, SARS, MERS and influenza.

Exclusion criteria
Language: non-English language
Context: Non urbanised contexts or sites irrelevant to the function of urban contexts
Intervention: pharmaceutical interventions or vaccinations
Disease type: non respiratory diseases or diseases not spread by airborne droplets (such as cholera, HIV/AIDS, Ebola, Dengue fever)
Contagion type: Studies of outbreaks of epidemics or endemic diseases (i.e., non pandemic)

The review process results are shown in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Fig. 1 below. Our search across databases returned a total of 1323 sources. Duplicates were removed, leaving a total of 792 articles. Six hundred articles were excluded based on our screening of abstracts and titles against the criteria in Box 1. Of the remaining 192 full-text articles reviewed, 65 were excluded. During data extraction a further 35 were excluded. The final number of included articles was 92.

A formal quality appraisal tool was not used in this review, due to the markedly different disciplinary, empirical and epistemological approaches used within the studies included.

2.3. Data analysis

The completed data extraction framework was reviewed by the first author. Each entry was re-reviewed and categorised under draft 'themes'. Essentially these themes were developed to represent the core focus of a body of articles and provide a categorisation of how the literature characterises urban planning, design and pandemics. Recalling that this was a rapid review that included 92 papers, there is considerable overlap between themes and papers crossing themes. The thematic analysis is essentially grouping based on eliciting 'what is most interesting about these papers in relation to our research question?' These draft themes were discussed with the second author for clarity and

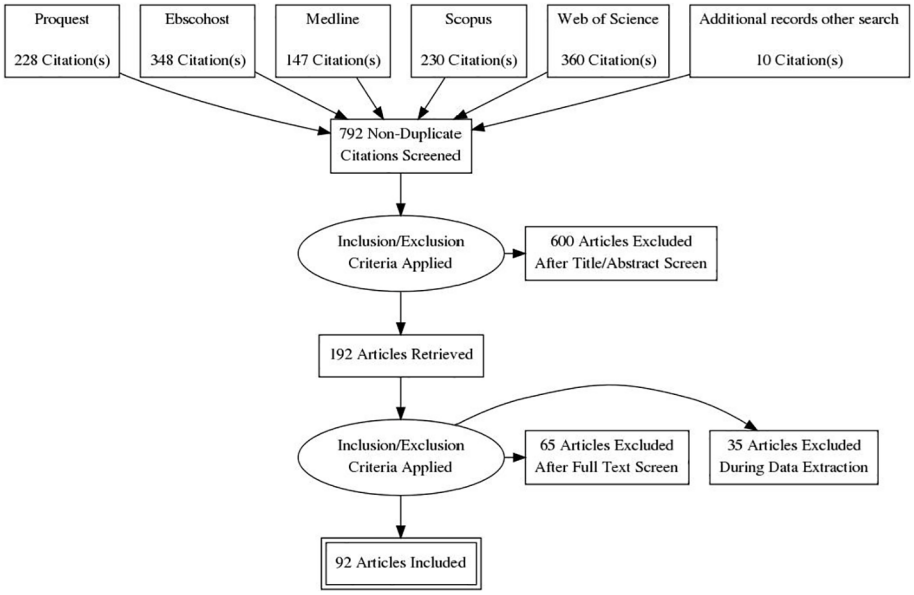

Fig. 1. PRISMA.

whether the themes accurately covered the content of the reviewed papers. A summary table (example presented as Table 1 below) was developed to capture the core content of each paper grouped under each theme. This table was then discussed with the full authorship team, who then further reviewed how the papers they had initially reviewed were included in the summary table. Themes were further reviewed during the drafting of this manuscript.

3. Results

Several core results from our research question emerged across the body of the articles reviewed using the data extraction framework and then the summary table.

There was a varied mix of types of articles, ranging from reviews to opinion pieces. In addition, 30 articles were labelled 'empirical' to cover papers that included data collection and analysis. Other papers were coded as being 'historical analyses' or 'modelling' (which became its own theme). The overall lack of systematic intervention-based research can be partially explained by the novelty of linking urban planning and design to pandemics, specifically in relation to COVID-19, the short timeframes between the onset of the pandemic our review.

There was a range of diseases that articles focussed on. Forty-three explicitly concerned COVID-19. Other disease types (around ten papers each) included Spanish influenza and H1N1. The rest mostly were labelled generically as 'influenza' or 'pandemic influenza'.

Overall, the articles covered a range of contexts internationally. The literature mostly covered developed contexts, including China (with some LMIC contexts). Several papers compared cities or regions internationally. The largest number of papers focused on the US, China, United Kingdom, and Italy, with fewer studies focussed on Australia, Mexico, India, Iran, Vietnam, Sweden, Canada and Japan. In several articles, New York, Wuhan, Hong Kong, Milan, and Mexico City were explicit cities of focus. Fewer articles focused on specific cities such as Toronto, London, Singapore, Santiago, Beijing, and Boston. For instance, some articles compared cities such as Luxembourg and Dublin, as examples of globally-connected, tourism-focused cities. Given our inclusion of only English language papers we did not find any papers from the African sub-continent or eastern Europe, Russia, or other non-Western contexts, with the important exception of China.

Explicit inclusion of equity considerations was not immediately apparent from the review. Equity is more than describing how the pandemic impacts specific population groups and requires actions to address power in systems and societies to redress unfair and avoidable disadvantage (Harris et al., 2020). There was some consideration of these factors and social conditions, especially in the literature on socio-environmental conditions (see below). However, by and large, equity was poorly covered.

3.1. Specific themes

Ten themes, presented below in alphabetical order (see Fig. 2), were identified as addressing the study's research question.

3.2. Scale, global to local

The urban scale hypothesis was confirmed as core to the body of knowledge reviewed. Articles covered globalisation and international and regional spread through travel to countries, regions, cities, localities, buildings, communities, and individuals. Globalisation driving city to city connection, often via air travel, was central to this literature. 'Relational cities' that are dependent on international capital flows were identified as being at greater pressure to roll back NPIs to enable economic activity (Hesse & Rafferty, 2020).

A paper-based on interviews with SARS experts reinforced that the continuous nature of urban places at scale means that emerging infectious diseases travel faster than they ever have before in history (Ali

Table 1
Example of the summary table used for data analysis.

e.g., theme	(Intervention?) Focus	Ref	Finding	Study Design	Disease	Context	Equity	Scale
Design and built form	Health and safety conditions of apartment buildings in Hong Kong	(Ho et al., 2008)	When differentiating healthy buildings, the management factors dominate the design factors	Empirical study - site inspections, desk research and interviews	Generic (SARS given as an example)	Hong Kong	Communication from developers to owners	Building
NPIs	Transmission control measures during the first 50 days of the COVID-19 epidemic in China	(Tian et al., 2020)	suspending intracity public transport, closing entertainment venues, banning public gatherings	empirical (secondary data analysis)	COVID-19	cities in every province across China	none	Country
System preparedness	Pandemic Influenza Planning in New York City	(Weisfuse et al., 2006)	Phased regulations following WHO phases for managing city during a pandemic	Commentary	Pandemic Influenza	New York	Communication plans to reach diverse and vulnerable populations	City

Fig. 2. Characteristics of the literature linking Urban planning and design to pandemic.

et al., 2006). The experts suggested that this phenomenon requires planners to reassess their role in policy making and implementation for containment and treatment of infectious disease. A systematic review of how urbanisation influences the epidemiology of respiratory and faecal infectious diseases similarly concluded that controlled and thoughtful urbanisation, sensitive to local contexts, can produce substantive economic and health returns at an individual city level and worldwide (Alirol et al., 2011).

3.3. Built environment

Six studies fell under the theme of 'Built environment'. This theme refers to the physical and built environment interventions or actions within buildings, streetscapes or localities. The reviewed literature suggested a close interface between buildings and streetscapes and their design to better prevent and respond to respiratory pandemics.

Within-building design is heightened in the context of social isolation (at home), or the need in some countries and settings where working from home is less possible (and so offices become crucial). Two studies emphasised ventilation to improve air flow in office buildings (Gao et al., 2009) and residential apartment buildings (Li et al., 2005). Away from the technical considerations around ventilation, a related article identified the importance of management of health and safety conditions in terms of preparedness and describing owners' responsibilities (Ho et al., 2008). Ventilation from temporary hospitals set up to deal with pandemics was modelled in one study (Gu et al., 2020).

Changing scale from buildings to open spaces, high-quality urban design is necessary to prevent and respond to respiratory pandemics. Essentially, this means creating high-quality open public spaces that facilitate NPIs and behaviour that minimises the risks of viral transmission. For example, a historical analysis of the Spanish Flu outbreak in Harrisburg, US, showed the importance of connecting an urban reform movement focussed on beautiful public spaces with the behavioural interventions (staggered work-times, lockdown) necessitated during that pandemic (Carter, 2020). A more recent reflective article suggested that 'post-pandemic places' required changing architectural rules to ensure spaces and places where people gather are designed to aid in mixing human interaction with distancing (Melone & Borgo, 2020).

3.4. Governance, deliberation and ethics

We grouped nine studies under the theme 'Governance, deliberation and ethics'. The theme concerns articles that emphasise the configurations of actors and stakeholders involved in governance surrounding pandemic-focussed urban planning and design. Most of the papers with this theme as their focus explain how governance at the city, especially local levels, is a critical point for ethically-informed deliberative engagement with the public about preparing for and responding to pandemics.

In terms of scale, studies positioned cities and city regions at the front line of coordinated leadership and action on COVID-19; the susceptibility of cities means a city governance framework across sectors is required (Sharifi & Khavarian-Garmsir, 2020). Urban localities are described as the first line of defense, with health governance linked to the institutional structure of cities and city autonomy within the hierarchy of national governance arrangements (Hoffman, 2013). Even where clear national guidelines exist, effective pandemic responses nevertheless were shown to depend on plans regarding local government level coordination—focusing on mitigation, preparedness, response and recovery (French & Raymond, 2009).

Institutions hold power over policy-making governance by influencing ideas, actors, and the rules and mandates that govern action and responses (Harris et al., 2020). For example, a historical analysis of the role of public health leadership in the U.S. responding to 1918–19 influenza pandemic suggested investing in strategic commitment to public health across sectors is required during and between pandemics (Higgins, 2020). Another paper emphasised how city leadership in a pandemic requires a combination of hard work and activation of

administrative, technological, political, and biomedical skills (Wolf, 2017). Another article found that institutional coordination across representative and multiple agencies and different jurisdictions is required in addition to individual skill (French, 2011). As an example, another paper found that at an institutional level the effectiveness of school closures in the U.S. during the 1918 influenza pandemic was shown to be dependent on both clear lines of authority among agencies and transparent communication between health officials and the public (Stern et al., 2009).

Paying attention to the ethics of communicating risks and responses came across as imperative within the literature reviewed under this theme. For example, law-enforcement and medically-driven surveillance to stop the spread of disease should be recognised as an ethical issue facing cities (Hoffman, 2013). In addition, several studies emphasised engaging with diverse communities with timely information as an explicit ethical element by anticipating and respecting diverse values, beliefs and cultures of community differences (French, 2011; French & Raymond, 2009). For example, one study showed how the allocation of scarce life-saving resources necessarily in two socio-economically different urban areas involves close alignment of decision-makers and service provider expectations that consider community diversity (Biddison et al., 2014). A separate paper argued that transparency, clarity and openness in decision making are required to generate necessary public understanding and support for implementing often difficult measures in the public's interest (French & Raymond, 2009).

3.5. Modelling

A body of 12 papers stood out as distinct and interesting because these articles chiefly focus on modelling to characterise the links between cities and pandemics. The theme refers to data modelling of social and environmental outcomes of strategies used to prevent or manage the spread of respiratory infectious disease in urban settings and at different scales.

The modelling literature was most often associated with modelling the effectiveness of NPIs, spatio-temporally in quite different geographic localities (China, Peru and the US) and for different types of respiratory pandemics (ZhiDong et al., 2010; Towers & Chowell, 2012; Mao & Bian, 2010). Some papers (Simsek & Kantarci, 2020) position the use of data modelling itself as an intervention to prevent disease spread. Others caution that mathematical models tend to oversimplify complex biological systems involved in pandemics (McVernon et al., 2007).

Concerning COVID-19, several articles using retrospective data analysis from Wuhan showed the effectiveness of limiting the spread through early urban-focused lockdowns (Prem et al., 2020; Yuan et al., 2020). In contrast, predictive modelling of NPIs and hospital service across the UK demand predicted unprecedented burdens of cases and deaths (Davies et al., 2020).

Transmission via transport was a subtheme of these papers. In New York City the subway was modelled as having limited impact on influenza transmission (Cooley et al., 2011). In Japan, modelling modifications in people's transport patterns was shown to facilitate social distancing (Ohkusa & Sugawara, 2009). In Wuhan, China, in one study modelled the effectiveness of nationwide transport restrictions combined with lockdowns (Yuan et al., 2020). Internationally, modelling suggested airports as the most efficient (but also the most expensive) locations at which to most effectively control the spread of infections (Chen et al., 2017).

3.6. Non-pharmaceutical interventions

Non-Pharmaceutical Interventions (NPIs) were defined as social interventions used to reduce respiratory infectious disease transmission. The ten studies under this theme demonstrated how urban planning and design support the effectiveness of NPIs as defined by WHO (2019) across handwashing, social distancing, reducing overcrowding, enhancing ventilation (temporary), school and business closures, household quarantine and suspending or reducing travel.

In China several studies showed how cities can support NPIs early in a pandemic. The early response to COVID-19 demonstrated the effectiveness of mass quarantine and limiting population movement (Taghrir et al., 2020). Suspending intercity transport, closing entertainment venues, and banning public gatherings were early successful NPIs in urban China (Tian et al., 2020). Given the globally interconnected nature of Chinese cities, another study showed that closing international travel connections between China and the world decreased the rate of case exportations during the early stages of the epidemic, delaying the onset of outbreaks in cities yet to be affected (Wells et al., 2020).

An historical analysis of US cities responses to the 1918 influenza concluded that no single NPI intervention was sufficient, arguing that 'only a vaccine is definitive solution' (Morse, 2007). But this study found some urban NPIs more useful than others, namely closing schools, churches and theatres. Timing also matters. This study and another US study about the 1918 influenza (Hatchett et al., 2007) showed NPIs were more effective in cities that implemented them early, while influenza returned if interventions relaxed too soon. Both studies also showed that long term support and compliance by citizens is a necessary precursor to success.

Other relevant literature under NPIs included the capacity to implement guidelines in school settings in NYC to prevent H1N1 (Agolory et al., 2013) and preventing the spread of SARS during sports participation in Hong Kong (So et al., 2004).

3.7. Socio-environmental factors underpinning pandemics in urban settings

The largest number of papers (N = 18) were grouped under this theme, defined as social and environmental factors that influence respiratory pandemic outcomes in urban settings. This body of literature emphasises epidemiology and historical descriptive analysis of large data sets covering spatial patterns in transmissibility and mortality impact. The reviewed literature captured important urban planning and design features of pandemics due to density and geography at city and regional levels. Compared to other themes, most papers referred to inequities faced by different social groups, suggesting the need for local approaches to identify and intervene to improve community susceptibility and levels of resilience.

The relationship between population density and respiratory pandemic infections was tested as a central proposition the majority of papers reviewed, usually investigated by comparing rural and urban regions. A comparison of provinces in the Netherlands found no clear relationship between density, urbanisation and COVID-19 (Boterman, 2020). Notably a study based on Spanish Flu data from soldiers returning to US cities and regions in 1918 was less conclusive, finding fewer infections rates in rural areas (Paynter et al., 2011). A study on the 1918–19 influenza pandemic in India suggested higher mortality rates in denser urban areas (Chandra et al., 2013). Influenza mortality rates in the UK in 1918–1919 were described as 30–40% higher in cities and towns than rural areas, but within rural areas, smaller areas had higher mortality rates, and transmission rates were not found to be different between urban and rural areas (Chowell et al., 2011).

A comparison of US Metropolitan counties found that urban connectivity between counties matters more than urban density (Hamidi et al., 2020). Connectivity between districts was also found to be an important factor in mortality during the 1918–19 influenza Pandemic in Portugal (Nunes et al., 2018). A study of 66 large US cities during the 1918–19 influenza pandemic found smaller cities suffered a disproportionately large mortality burden compared with larger cities (Acuna-Soto et al., 2011). The study explicitly explained why connectivity matters over and above density by showing that NPIs were confounders between density and infection rates (Hamidi et al., 2020). The authors

concluded that urban planners and local governments have a role in supporting NPIs while maintaining advocacy for compact development.

Similarly focussed on confounders to density, an international comparison suggested that density and COVID-19 were confounded by NPIs and the quality of hospital care systems and patient characteristics (Signorelli et al., 2020). The authors argue that higher-quality hospitals in larger (denser) metropolitan areas and fewer at-risk populations like the elderly meant reduced infection rates (Signorelli et al., 2020). Similarly, in Mexico, a comparison of morbidity from H1N1 in regions observed the lowest incidence rates observed in large population centres. The authors suggest this may be due to health-seeking activity in larger cities/centres or more effective social distancing (Chowell et al., 2008). Socioeconomicc factors play a significant role in the spread of pandemics. A US study about susceptibility to COVID-19 suggested that population density is the largest contributor to susceptibility in large metro areas, with the authors suggesting socioeconomic factors play a significant role in the potential spread of the disease (Peters, 2020). A UK national comparison of mortality rates from H1N1 against socio-economic deprivation found that the most deprived quintile of England's population suffered an age and sex-standardised mortality rate three times that experienced by the least deprived quintile, and that age and sex-standardised mortality rate was higher in urban areas than in rural areas (across deprivation) (Rutter et al., 2012). Spatial disparities in transport infrastructure were shown to matter in a study quantifying the H1N1 outbreak impacts which found that both the road transport network and socioeconomic status were correlated with the outbreak (Xu et al., 2019). Finally, another article demonstrated that migrant workers/internal migrants were not disproportionately responsible for the early spread of COVID-19 in China (Shi & Liu, 2020).

In Wuhan, China, COVID-19 outbreak areas were identified in one study as all high density residential areas (Peng et al., 2020). Looking more deeply at urban planning and the urban form, another study of COVID-19 in Wuhan showed clear distribution of COVID-19 morbidity mainly based around the intensity of economic activity and design and positioning of buildings to encourage density (You et al., 2020). The authors concluded that urban development based on principles of sustainability, open space, and the spread of smaller commercial operations across urban areas, with an increase in hospital and public service facilities required to prevent pandemics like COVID-19. The shift from agrarian to urban ways of living were identified as a risk factor for Avian Influenza in a study in Vietnam, with infrastructural interventions required at household, community and district levels – especially around water supply and sanitation (Hamidi et al., 2020).

A study of 55 Italian provinces argued that transmission dynamics of COVID-19 is due to air pollution-to-human transmission rather than human-to-human transmission (Coccia, 2020). However, an Australian study that investigated the spread of influenza strains argued that transmission is less about the characteristics of the place in terms of climate and distance, and more about connectedness and density (e.g. human to human connection), concluding that public health rather than environmental interventions are crucial (Geoghegan et al., 2018).

3.8. System preparedness

This and the next theme add an important temporal dynamic to the review's findings. Both differentiated urban planning and design prior to (preparedness, this theme) and following (response, next theme) the advent of a respiratory pandemic.

The system preparedness theme, covering 15 papers, was defined as the design of urban systems set up to prevent or prepare for respiratory pandemics. Most papers under this theme had a prospective orientation to what systems should look like to prepare for pandemics. There were also some retrospective evaluations of how system design held up after the fact. A few papers focussed on developing guidance documents. In terms of content, the papers demonstrate that preparedness must occur between pandemics and that early pre-emptive action is essential. Pandemic guidance exists (CDC, WHO) for multi-level preparedness. Scale again is crucial, with support for local responses lifting their strategic gaze to regional and macro drivers and risks.

One practical paper is premised on COVID-19 throwing into sharp relief the need to ensure systems and capacities of cities to make them resilient to prevent spread of infectious diseases (Capolongo et al., 2020). The paper emphasises collaboration across sectors and disciplines with an urban health focus. A 10-step list of 'public health opportunities' for city planning in the immediate and longer terms is provided. These notably pay attention across the urban scale from individual private space to neighbourhoods to whole of city. Smart cities and digitisation are crucial.

Similarly, a review of pandemic resilient cities showed these are achievable by addressing resilience at 3 scales - housing, neighbourhoods/public space, and cities (Lak et al., 2020). Connectivity is crucial, the review showed; Intercity and intra city transport systems, airports, ports, hubs, CBDs and other centres of dense transactions pose essential threats to urban areas and make them vulnerable to pandemics. Addressing these scales requires interdisciplinary creativity and innovation in technology, science, medicine, ethics, legal systems, socio-political systems as well as urban planning and design.

Guidance and preparedness planning has substantial historical precedence in previous pandemics, especially the 1918–19 influenza (Ott et al., 2007). Relatedly, a study compared historical guidance (1921) with 2007 guidance and showed close similarities (Morens et al., 2009). A Centres for Disease Control 'Morbidity and Mortality Weekly report' from September 2014 explained updated pandemic influenza guidance (Holloway et al., 2014). Preparing for outbreak at specific intervals is presented, followed by 8 domains to organise response efforts within each interval.

A New York City focussed paper explained how the WHO phases for managing cities during a pandemic include broad planning goals and emergency measures; for example, establish continuity plans for critical government agencies and infrastructure partners in utilities (Weisfuse et al., 2006). Another paper found that pandemics (the 1918–19 influenza was mentioned) require mass fatality management plans for cities and regions (Stanley, 2010).

Different types of transport were related to the spread of pandemics in urban settings. Regionally in China, the substantial city to city spread of COVID-19 via transport meant that one paper concluded that travel bans would have been more effective if implemented earlier (Zhang, Chen, et al., 2020). Another paper found a significant and positive association between the frequency of flights, trains, and buses from Wuhan and the daily as well as the cumulative numbers of COVID-19 cases in other cities with progressively increased correlations for trains and buses (Zheng et al., 2020). The authors recommend that labour intensive cities require strong measures to prevent future outbreaks caused by 'population reflux'. A discussion paper generic to respiratory pandemics recommended bio resilient transport infrastructure, with public health security incorporated across the life cycle phases of critical urban infrastructures, including transport, from design and planning to upgrading/decommissioning (Nasir et al., 2016). A Singaporean study found that using bioaerosol samplers in crowded public spaces to non-invasively monitor respiratory viruses may have relevance for densely populated, well serviced settings (Coleman et al., 2018).

Other studies covered public preparedness (e.g., health literacy), infrastructure preparedness, and institutional governance/response preparedness. Two papers focused on Italy emphasised sustainable urban planning for cities; preventing urban heat island and poor air quality are hypothesised as also preventing COVID-19 risks (Leone et al., 2020; Murgante et al., 2020). In Shenzhen, China, community containment of COVID-19 required prevention programs established multidisciplinary team by city government to investigate spread and implement measures to encourage early identification and quarantine (Zhang, Zhou, et al., 2020). Another paper from Beijing shows that health literacy in the community was found essential in forming

interventions and responses to H1N1 (Zhang et al., 2014). Finally, a novel but important paper concerned the maintenance of water infrastructure as critical infrastructure during a pandemic (van Atta & Newsad, 2009). The paper reviewed preparedness plans and surveyed 86 medium to large water systems in Ohio, highlighting the need for contingency plans for continuity of operations in the face of the reduced workforce and potential disruption of supplies, chemicals, and energy.

3.9. System responses

This theme was complementary to the previous but refers to responses once pandemic outbreaks occurred. Overall, the seven studies included under this theme showed that the global nature of the pandemic requires action at local levels. Communication with communities is crucial. Smart cities—social media, remote working—is an important modern part of the urban response.

Technology was seen as central to response systems in several ways. One article about the post-pandemic response in Milan makes useful, formative observations about maximising mobility at the street level through the use of new developments in urban informatics and data (Deponte et al., 2020). The rationale is that subways and trains will be used less, but that the aim should be to stream-line car use and maximise options for 'soft' or slow mobility (bikes, pedestrian mobility). As part of 'tactical urbanism' people can highlight areas of the city or streets that facilitate or constrain movement and mobility while retaining physical distancing.

Also technology focussed, a study analysed early social media data from Wuhan in China (Han et al., 2020). The authors reported that social media engagement may help inform communication strategies related to pandemic crisis management at a temporal-spatial scale and establish a hierarchical emergency response mechanism: region–province–city.

Facilitated by technology, remote working is an important part of a response system in the short and long terms. However, this comes with challenges. Some countries, like Japan, are (counter-intuitively given their high levels of technology industry) not well adapted for remote working or even lockdowns (Tashiro & Shaw, 2020). Another paper argued that remote working can risk prolonged detachment from reality with loss of a sense of physical places negatively impacting remote workers' identity construction (Errichiello & Demarco, 2020).

Communication to encourage responsive behaviour in local, often diverse, communities was the focus of several studies. One study compared urban community responses to H1N1 in Mexico City (high pH1N1 case ratio) with two distant cities (lower case ratios) (Aburto et al., 2010). The findings showed no difference in messages and adopting one or more NPIs. However, socioeconomic deprived communities found some messages confusing and economic barriers to adopting recommended behaviours were sometimes reported. Another Mexican paper observed use of face-masks to prevent H1N1 outbreak in Mexico City in different public transportation settings, and mandatory for bus and taxi drivers (Condon & Sinha, 2010). Insufficiently severe penalties diminished mandatory use of face masks. Stronger penalties for non-compliance created more substantial economic incentives for taxi drivers to wear masks.

Establishing critical health focussed infrastructure in early responses to COVID-19 was shown to be important in an article describing how large-scale public venues were used as medical emergency sites in Wuhan, China, (Fang et al., 2020). Venues provided essential living and medical conditions for isolated patients with mild symptoms as well as for suspected patients. Appropriate layout design, electricity, and waste management is necessary. Most of the ventilation required replacing. Venues needed to be located in the centre of an urban area but away from susceptible areas, accessible by major arterial roads, and have spacious indoor space with reliable power.

3.10. Underserved or vulnerable populations

Some literature focussed on particular population groups that were vulnerable to respiratory pandemics. While not fully addressing our research question about equity (which requires consideration of structural determinants of inequity), considering vulnerable populations are part of equitable urban pandemic focused planning and design. The five papers included were mixed in terms of content. The literature reviewed included people with disabilities being at the forefront of pandemic focussed city planning and design (Pineda & Corburn, 2020), beliefs of elderly Canadian Chinese as an example of nuanced cultural beliefs about pandemics (Wills & Morse, 2008), geospatial mapping of risks of spreading the virus in the Iquitos neighbourhood of Peru (Vazquez-Prokopec et al., 2013), suppression of COVID-19 transmission among the homeless population and care for positive cases in Boston (Baggett et al., 2020), and ethical distribution of vaccines for the homeless and underhoused (Buccieri & Gaetz, 2013).

3.11. Future proofing urban planning and design

This final theme covered three papers that presented a future orientation to what planning and design should or could look like post-COVID-19. Each paper recommended reforming current policy systems to give urbanists more influence (often as part of public health planning). Two papers under this theme (and from the same COVID-19 focussed journal issue) asked readers to imagine new forms and organisational structures for multi-municipal places and spaces (Fasolino et al., 2020), with one arguing for reform across all policy domains of territorial governancee: from tax to buildings (Pontrandolfi, 2020). In response to the Chinese locking down cities in response to COVID-19, the third paper under this theme exhorted better involvement of planners in disaster management and public health planning, including better use of urban technology, data and urban informatics to support disaster preparedness and management of pandemics (Allam & Jones, 2020). The authors suggest that pandemic preparedness protocols be part of long-term urban planning and design strategies.

4. Discussion

This rapid review has identified and characterised the known historical literature on urban planning and design and respiratory pandemics. We have shown how the literature has tended to cover 10 domains, centred around a multi-scalar understanding of cities. At its core, the body of literature we reviewed explains and establishes the links between planning and designing cities to stop or mitigate the spread of respiratory pandemics.

Our rapid review of historical evidence about cities and pandemics supports known urban theories. We have shown how pandemics over recent history are spread essentially because cities are globally interlinked and scaled from global to local (Brenner, 2019). We have shown how pandemics have historically required urban design responses and mitigation strategies beyond aesthetics to amenity and supportive urban governance (Punter, 2007).

We undertook this review during the early phase of COVID-19's spread in 2020. With hindsight it is now clear that the core strategies and interventions suggested in the historical literature are essential to pandemic planning – see also a recent COVID-19 and urban design review (Sharifi & Khavarian-Garmsir, 2020). That literature has covered most, although not all, city planning and design dynamics; from an emphasis on air travel as a super-spreader between cities, attending to the connectivity between cities as being as or if not more important than urban density, down to ensuring governance frameworks are in place and that diverse communities are engaged and able to take on messages and core public health interventions.

The quality of the evidence was not our concern. Indeed, the ten domains we have characterised the literature against would not change,

regardless of the quality of the literature. We feel confident in suggesting that this review has adequately captured the complexity of urban planning and design and pandemics. That said, our review did suggest enormous scope for developing a robust and complex body of findings from the recent experiences with COVID-19. With the multi-scalar core, the ten domains provide a framework for a body of future research and policy action.

There are some gaps in knowledge. Equity, which requires a definition addressing the structural determinants of pandemics across and within cities, was poorly covered. There was some descriptive data on equity included in the socio-environmental body of literature. Such knowledge is necessary but insufficient if cities are to plan and respond to the inequities evident during COVID-19 (Marmot & Allen, 2020).

More research is required across all domains. The role of infrastructure and pandemics was noticeably most underdeveloped from a policy perspective - for example see (Newman, 2020). Infrastructure has a twin function concerning pandemics. On the one hand, the reviewed literature suggested how the planning and design of infrastructure is crucial for halting the spread: planning and designing transport infrastructure such as airports and public transport, down to local built infrastructure ensuring people engage with their local environments but do so in well ventilated places and spaces that encourage physical distancing and movement. On the other hand, the literature did not capture the economic potential of infrastructure either in preparing or responding to pandemics. The links between infrastructure, agglomeration, and pandemics for instance is an area which needs careful investigation: the leap to politicise the economic importance of infrastructure without adequate understanding of what that infrastructure means for a post-COVID proof society demonstrates this need for caution. Technology will be a core part of any analysis of infrastructure and pandemics.

4.1. The review has some strengths and limitations

Our multidisciplinary approach was a success in terms of process, given that we were able to harness a broad swathe of perspectives and expertise in the design of the review as well as the reviewing itself. The rapid review allowed us to move beyond narrow review questions that limit scope for multidisciplinary learning in our response to COVID-19 and future respiratory pandemics.

Our respiratory focus requires caution. Some other form of pandemics may have relevant lessons but were excluded on the basis of focus and feasibility. Our rapid review means not all interventions may have been identified, and there may have been lessons from pandemics prior to 1900 that were not fully integrated. Finally, knowledge in this area is evolving quickly. When we began this review, most of the available literature on COVID-19 and the intersection of urban planning, design and public health was commentary or opinion articles. This article has shown the many and potential areas for future high-quality knowledge generation to strengthen the urban connections to pandemic planning and responses.

5. Conclusion

In conclusion, understanding cities and pandemics as multi-scalar is a crucial finding from our review. Thinking in this type of scale for pandemics is both practical – this is how the virus becomes a pandemic via cities – and supports well known urban theory (Brenner, 2019). In the absence of immunisation, for COVID-19 or other future pandemics – high quality city planning and design which is preventative and responsive at the local level while understanding the global nature of pandemics, is essential. There is a sizeable body of urban planning, design and public health literature that highlights the potential intersectoral, interdisciplinary and collaborative interventions to address anticipate, respond to, and redress the impacts of respiratory pandemics. This review has connected that body of work into a coherent whole to structure necessary future research and policy responses.

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CRediT authorship contribution statement

Patrick Harris: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Ben Harris-Roxas:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Jason Prior:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Nicky Morrison:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Erica McIntyre:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Jane Frawley:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Jon Adams:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Whitney Bevan:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Fiona Haigh:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Evan Freeman:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Myna Hua:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Jennie Pry:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Soumya Mazumdar:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Ben Cave:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Francesca Viliani:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Benjamin Kwan:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing.

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