Urban climate-health governance: Charting the role of public health in large global city adaptation plans

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Abstract

Over the last decade many large world cities have scaled up efforts at climate adaptation, a primary focus of which is protecting population health. With extreme weather disasters increasing worldwide, public health agencies are among local institutions under greatest stress; the Covid-19 pandemic has only heightened pressure on these agencies. Yet the limited literature examining adaptation actions across world cities suggest few, mainly high-income cities report health-related adaptation, while city public health agency engagement in adaptation has received little research attention. In this comparative review, we aimed to characterize the public health role in the adaptation plans of 22 large cities pre-identified as highly health-adaptive, by examining five health-associated adaptation activities chosen as “promising practice” based on evidence synthesized from evaluation research and practical experience: (i) hazard and vulnerability mapping; (ii) extreme weather preparedness and response; (iii) extreme heat plans (including heat early warning); (iv) non-heat early warning (e.g., flooding, vector-borne disease); and (v) climate-health monitoring and outcome surveillance. We found most (90%) city adaptation plans reported actions in at least three of these five activity areas. However, only 73% of these health-focused plans reported involvement of a public health agency (though the share was higher for cities in low- and middle-income countries). We detected differences across the five activities, including an ascending pattern of public health engagement starting with heat plans and including activities such as preparedness and mapping as health agency involvement increased. We also identified substantial presence of other city agencies—notably urban planning, emergency management and public utilities—in implementing these health-associated activities. With every world region likely to experience more widespread and intensifying climate impacts, and growing pressure on local public health agencies in conjunction with the Covid-19 pandemic, we identify opportunities for enhancing public health engagement in climate adaptation in large cities with a view to scaling up their ability to contribute to climate adaptation goals.
Introduction

The world’s cities are major consumers of fossil-fuel energy and producers of greenhouse gas (GHG) emissions [1], making their actions to decarbonize essential to reversing anthropogenic global warming and achieving the goal of the Paris Agreement to remain within 1.5 degree C of additional global surface warming this century. Cities are rising to this challenge through net-zero emissions targets, phased plans toward greener transport, more renewable and efficient energy use, and other practices [2]. The warmer more extreme weather brought by a changing climate also disproportionately affects cities [3, 4] which are vulnerable due to their dense populations, the urban heat island (UHI) effect, and frequent location on coasts and inland waterways. With growing awareness of urban vulnerability to short-term hazards such as heat, storms and flooding, and of likely irreversibility in human generational timescales of some longer-term hazards such as sea-level rise [4] and drought [5], city decision-makers have increasingly understood the parallel imperative of adaptive action to protect urban residents.

As a result, over the last decade many cities have added population-focused adaptation planning to their climate strategies [6, 7]; and city climate change networks such as C40 Cities and others, which have helped disseminate innovation and experience across cities on climate mitigation, have also expanded into adaptation [8].

City decision-makers often have greater awareness of local adaptation priorities than those at other government levels [9], and cities in many regions have responsibility for functions affecting population wellbeing, including public health agencies or departments, often with some degree of autonomy over health-related activities. In addition, cities are increasingly concerned about the pressure climate change is placing on public health institutions: an international survey of 740 cities recently found a majority felt these agencies were under greater near-term climate-related stress than other city agencies [10]; the Covid-19 pandemic has only compounded these pressures. Large cities (those with populations over one million) present particularly important population health and wellbeing risks due to the sheer number of people potentially affected by climate-driven extreme events and their interactions with complex urban infrastructure systems [11]. While large cities in high-income countries have borne significant damage to physical assets with recent extreme weather events, fast-growing large cities in low- and middle-income countries are among those with the greatest numbers of people at risk [12].

Climate adaptation—“seeking to moderate or avoid harm, or exploit beneficial opportunities” according the Intergovernmental Panel on Climate Change (IPCC) [13]—is aimed in large part at safeguarding population health and wellbeing and building community resilience to climate-related risks [14]; these risks can be due either to direct harms from hazards such as extreme heat and flooding, or to indirect impacts of hazards mediated through the built, social and natural environment [15, 16]. General categories of adaptation effort comprise infrastructure protection, technology, institutional and behavior change, natural resource management, risk transfer, and information and risk communication [17]. Particularly for low- and middle-income countries, adaptation actions often overlap with sustainable development goals (SDGs) such as improved water, sanitation, housing, health and urban services [18]. Recent work has emphasized the importance of building on the linkages between health-related adaptation planning and the Sendai Disaster Risk Reduction Framework, including multi-hazard early warning and preparedness [19, 20]. Meanwhile, UN Habitat’s New Urban Agenda recognizes that urbanization is one of this century’s most critical transformations, and sets out an ambitious framework for sustainable city planning, governance and finance in support of the SDGs [21]. Taken together the Paris Agreement, the Agenda for Sustainable Development and SDGs, the Sendai Framework, and the New Urban Agenda can be seen as key foundational guidance for building low-carbon, climate-resilient, health-adaptive and sustainable cities.
Although formal adaptation evaluation is scarce [22], research has begun to better delineate key component parts of “promising practice” in health-related adaptation most relevant for cities [16]. The IPCC has identified a number of adaptation strategies important to reducing health and wellbeing in urban areas, including vulnerability mapping, early warning systems, monitoring and surveillance [17]. The Global Commission on Adaptation also includes early warning and resilient infrastructure for water and other services among its priority recommendations [23]. Extreme heat early warnings have been found likely to be cost-effective in protecting populations [24], and recent work has synthesized experience and fine-tuned guidance on broader extreme heat action plans of which such warnings are often part [25–27]. Efforts to develop early warning for climate-related infectious diseases have also advanced [28, 29]. Preparedness and response actions such as training and drills for at-risk communities as well as first responders, considered “health-related” by the Lancet Countdown on Health and Climate Change, [7] have undergone increasing study; while a large literature has emerged on “nature-based solutions” such as urban greening and sustainable stormwater management that support multiple benefits for extreme temperature, precipitation and flood preparedness in cities [30–32].

Yet the synthetic literature examining health-related adaptation and the role of public health agencies across large global cities remains limited. A comparative review of five Mediterranean cities’ adaptation plans examined climate drivers and adaptation policy tools; extreme heat management was a common feature [33]. Another comparative review of publically-available climate adaptation for 42 large cities found most aimed at behavior change rather than capacity building, information or infrastructure actions; few cities in low- and middle-income countries were reported [34]. More recent research based on city reporting to an international adaptation database identified 98 large cities reporting health-associated adaptation actions (40% of which were in low- and middle-income countries), with half reporting information-related and one third reporting physical health determinants-focused actions; city network collaboration over time has likely helped drive this apparent increase in health-active cities [35]. In these studies, actions were largely aimed at protecting populations from near-term hazards, particularly extreme heat due to storms and flooding; they also identified gaps, including governance and capacity building, neglected health outcomes (e.g., mental health), need for greater public health engagement and cross-agency collaboration in adaptation planning, along with need for enhanced research and practice attention to cities in low- and middle-income countries. Notably, these studies did not assess the role of public health agencies in planning or implementing health-adaptive actions.

Thus, how and by whom these and other urban health-supportive adaptation actions and policies are planned and implemented, including by non-health actors, has yet to be fully characterized [36, 37]. Nor is it clear whether data available from public health agencies (including epidemiological evidence on exposure-health outcome associations, population vulnerability characteristics, and disease surveillance data) is being optimized within adaptation planning to target actions to the most vulnerable. For example, in the US, engagement of local health departments and health data has been shown to enhance targeting of climate adaptation through climate-health assessments [38, 39]; while an emerging research has begun to explore vulnerability indexes (including their validation) and mapping of hazards and risks [40, 41], as well as enhanced use of climate-health surveillance and monitoring within climate adaptation planning [42–45]. Knowledge gaps in health governance—here referred to as “attempts of governments or other actors to steer communities... in the pursuit of health as integral to wellbeing,” according to the World Health Organization (WHO) [46]—suggest the value of probing in a structured way the health-adaptive activities of large city adaptation plans. Better knowledge of core governance features, and particularly what role city public health agencies have in
planning and implementation of health-associated adaptation actions, will help ensure they are successful at meeting their objectives.

In this study we aimed to examine the climate adaptation plans of a pre-identified group of highly health-engaged large world cities to contribute to charting the role of public health in five promising urban climate-adaptive health activities: (i) climate hazard and vulnerability mapping; (ii) heat action plans, including heat early warnings; (iii) other hazard early warnings (e.g., landslides, infectious disease); (iv) preparedness and response actions; and (v) climate-related health monitoring and surveillance. Our broader goal was to identify opportunities for more effective planning and implementation of urban health adaptation actions as a means to achieve the goal of population resilience outlined in city adaptation plans.

**Materials and methods**

For this comparative review of large health-adaptive cities, we took the following four methodological steps: We first identified a group of highly health-active large cities; second, we searched for and retrieved climate adaptation plans for these cities from public sources available on the internet; third, we used the tools of systematic review (e.g., pre-determined questions related to role of public health agencies, and consistent data extraction protocols) to extract comparable data from all city plans; and fourth, we synthesized results and compared them across the city plans.

We identified a pool of highly health-adaptive cities from among those reporting to the CDP 2018 City Adaptation Actions Database. CDP hosts several global climate-related databases pooling information from member city climate change networks, including C40, ICLEI and others; the CDP’s Adaptation Actions Database is the most comprehensive, consistently-collected international source of city adaptation information available publicly, with self-reported actions collected and updated annually [47]. We chose to examine cities with populations over one million (referred to as "large cities") because they are often active in climate policy and many have direct public health responsibilities. We chose highly health-adaptive cities in order to ensure the largest potential number of health-associated adaptation actions to evaluate. Based on previous research involving 106 large cities, we defined "highly health-adaptive" as reporting to the 2018 CDP database substantial activity in the following health-associated adaptation categories: climate-health governance, climate-health information (e.g., early warning or surveillance), climate-health services (e.g., vector control), physical infrastructure supporting climate-related health determinants (e.g., for preparedness or urban greening), and climate-health capacity building; our threshold for "substantial activity" was the 75th percentile of actions across these categories for the cities evaluated [35].

Using these definitions, we identified 29 highly health-adaptive large world cities; 19 were located in high-income and 10 in low- and middle-income countries, per World Bank income category definitions [48].

To retrieve publicly-available climate action plans for these cities we carried out English-language internet searches using relevant search terms (city name plus terms for climate change, adaptation, and plan or strategy). We selected only adaptation plans dated 2016 and after, taking the December Paris 2015 United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) meeting as a cut-off point. We located publicly-available city climate adaptation plans for 22 of the 29 large world cities (S1 Table). We excluded seven cities for which we did not find unified adaptation plans (information limited to city network websites, press or agency reports, all of which we gauged insufficient for our analysis). Within the study team we implemented a cross-check procedure to verify city climate plan eligibility and ensure the largest number of comparable documents. We translated any documents not available in English.
Each team member read three or four selected city climate action plans, and based on a consistent, pre-defined coding protocol extracted basic data. These basic data included: climate plan title and date; type of plan (e.g., whether adaptation only or both adaptation and mitigation); agency responsible for developing or coordinating the climate plan; short summary statement of the plan’s goal; whether “health” or related terms (e.g., “wellbeing” or “vulnerability”) were included in this goal statement; and the primary climate hazards and climate-related health outcomes reported. We also extracted data on whether cities reported any actions in the five promising health activity areas for which the evidence base is growing: (i) climate hazard and vulnerability indexes and mapping; (ii) heat action plans, including UHI management and heat early warning systems (EWS) and alerts; (iii) other early warning systems (EWS) or alerts (i.e., for floods, landslides, infectious disease); (iv) extreme event preparedness and response actions; and (v) climate-related health surveillance and monitoring. We identified (when information was reported) whether public health agencies were engaged in implementation of these actions, and which other city agencies were also involved. In addition, we extracted commonly-reported strategies of the five activity areas and evaluated whether they were primarily population-protective or infrastructure-protective in their focus. In the case of several cities, we used regional or national climate plans, or climate-health plans where available, to enhance our understanding of city climate plans.

The data were transferred to an Excel spreadsheet, and extractions performed by one team member were reviewed and cross-checked by a second team member. One team member then performed an overall audit of the dataset to identify any inconsistencies in extractions across team members. Our initial review confirmed that all except one of our 22 city health plans included “health” or “wellbeing” in the goal statement, though characterized in different ways (often generally such as “health impacts of climate change”). We present our findings in the Results section primarily as number and share of cities reporting any actions in the five activity areas; and number, share and type of implementation agencies reported. We also report results of a brief additional analysis of adaptation plans for cities with the highest share of public health agency engagement, aimed at identifying in greater detail the specific role of health agencies. In the Discussion section we review findings and provide recommendations for opportunities to enhance urban climate-health adaptation governance.

Results

Our final group of 22 cities with available adaptation plans included 16 (Austin, Auckland, Baltimore, Barcelona, Boston, Calgary, Las Vegas, Lisbon, London, Paris, Phoenix, Salt Lake City, San Francisco, Tel Aviv-Yafo, Vancouver and Washington DC) in high-income countries; and six (Buenos Aires, Cape Town, Hong Kong, Kolkata, Quezon City and Rio de Janeiro) in low- or middle-income countries (S1 Table). The share of cities in low- and middle-income vs. high-income countries was 27% (slightly lower than our original identified city pool, which was 34%). All world regions were represented by at least two cities: ten in North America (45%), four in Europe (18%), four in Asia/Oceania (18%), two in Latin America (9%) and two in Africa/Middle East (9%). The total population of the 22 cities is over 120 million. The types of plans varied, but the large majority were either combined climate action plans addressing both mitigation and adaptation (45%, e.g., Hong Kong); or adaptation-only plans (32%, e.g., Rio de Janeiro). Several plans were more broadly resilience-focused (e.g., San Francisco), economic development plans that mainstreamed climate change (e.g., Auckland), extreme weather preparedness oriented (e.g., Baltimore), or broader environmental strategies (e.g., London).
Every city plan reported several climate-related hazards: extreme heat was reported by all cities (some also reporting drought and wildfire hazards) and 82% reported hazards related to extreme precipitation (including storms and flooding). Sea-level rise was reported as a hazard by all cities in the sample located on or near a coast (59% of cities). Over half of cities reported increasing air pollution as a climate-related hazard. All city plans also reported at least one specific population health risk associated with these climate hazards. Those most commonly reported were heat-related illness (HRI), including heat stress, heat stroke, cardiovascular disease (CVD) and kidney complications (with particular concern for the elderly, very young, and outdoor workers); and injuries, evacuations, property or personal loss, relocations and mental stress due to extreme weather (storms, flooding, landslides and wildfires). Also of concern were respiratory illnesses due to the combined effects of heat and air pollution. Vector-borne diseases (notably dengue fever and Lyme disease) and diarrheal water-borne disease (drought- and flood-associated) were mentioned, though infrequently (S1 Table).

All cities reported actions in at least two of the five areas of interest, and 90% reported actions in at least three; the most frequently reported were mapping (n = 21 cities), preparedness (n = 20) and heat plans (n = 18). The average number of activity areas reported by the low- and middle-income country group was higher (4.2 per city) than the high-income country group (3.4 per city) (S2 Table). All cities also reported at least some information on implementation agencies. Climate plan development was most frequently reported to be coordinated by a city council (e.g., Barcelona), a Mayor’s office (e.g., London) or a city office of sustainability or environment department (e.g., Baltimore). Public health departments or agencies were reported to be involved in the climate team in 73% of city plans, with the low- and middle-income country group reporting a higher share of public health agency engagement (83%) than the high-income country group (69%) (blue shading, Fig 1A and 1B).

Reported public health department engagement (blue bar, Fig 2) varied across the five areas, ranging from a high of 59% for heat plans, to 41–45% for mapping, preparedness and surveillance, to a low of 14% of cities for other (non-heat) warnings.

Notably, a higher share of health agencies compared to any agency was reported for surveillance and heat plans, suggesting more intensive health institution presence in these activities. We found a detectable spectrum of public health engagement across the five activity areas; this ranged from cities with less—which reported health department involvement in heat plans—to cities with more—which in addition reported engagement in mapping, preparedness and other activities (S3 Table).

Fig 1. Share of 22 cities reporting public health agencies engaged with climate adaptation plan team, by country income category.

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Among cities with health agency names reported (n = 18), the majority (n = 12) were city public health departments, while six were national or regional health departments or consortia; four cities did not report health agency names (S3 Table). Nearly one-third of cities (n = 6) did not cite involvement of a health agency for any of the five activity areas; of the remainder (n = 16), half reported health agency engagement in three or more of the five activity areas. We examined in greater detail adaptation plans for six of these cities (Baltimore, Barcelona, Kolkata, Rio de Janeiro, San Francisco and Washington DC). Each identified health as a distinct thematic pillar with public health agency engagement, although only three also integrated public health more fully into other non-health thematic pillars (Table 1).

In the full sample of 22 cities, implementation of the five health-associated activities was reported to be done in collaboration with many other city agencies in addition to public health. This ranged from over a dozen agencies in the case of preparedness (e.g., urban planning).

Table 1. Six cities with strong health department involvement in climate plans.

| City          | Public health agency name                  | Activities (Health dept) | Health a separate thematic goal in climate plan | Public health agency integration |
|---------------|--------------------------------------------|--------------------------|-----------------------------------------------|---------------------------------|
| Baltimore     | Baltimore City Health Department (BCHD)     | 5 (5)                    | Yes                                           | Yes                             |
|               |                                            |                          | “public services”                              |                                 |
| Barcelona     | Barcelona Public Health Agency (ASPB)       | 5 (4)                    | Yes                                           | Yes                             |
|               |                                            |                          | “health”                                       |                                 |
| Kolkata       | Kolkata Municipal Corporation Health Dept  | 3 (3)                    | Yes                                           | No                              |
|               |                                            |                          | “climate public health hazards”                 |                                 |
| Rio de Janeiro| Rio de Janeiro Municipal Health Secretariat (SMS) | 5 (5)                    | Yes                                           | No                              |
| San Francisco | San Francisco Health Department             | 3 (3)                    | Yes                                           | Yes                             |
|               |                                            |                          | “healthy neighborhoods”                         |                                 |
| Washington DC | Washington DC Department of Health (DOH)   | 3 (3)                    | Yes                                           | No                              |
|               |                                            |                          | “neighborhoods & communities”                  |                                 |

Activities: Number of health-associated activity areas reported (from among the five studied).  
Health dept: Number of health-associated activity areas in which health department is engaged.  
Public health agency integration: Whether health broadly is integrated across the climate plan.
emergency response, utilities) and mapping (e.g., weather, GIS services) to half a dozen for heat plans (e.g., energy, urban planning) and non-heat early warning (e.g., emergency response, insurance), to few or none in the case of climate and health outcome surveillance (Fig 3).

We did not find many cities that identified details related to agency roles and relationships. Washington DC was an exception where "leadership" and "partnership" roles were specifically designated for city agencies by activity in the climate plan (Box 1). There, for example, the

Box 1. Lead and partner agencies for health-associated activities in Climate-Ready DC

**Leadership:** The Washington DC department of health (DOH) is identified as "lead" agency in four “Neighborhoods and Communities” thematic activities in the city’s Climate-Ready DC plan: (i) outreach to community on heat and flood vulnerability (in collaboration with emergency management, housing, energy, office of ageing and other departments); (ii) evaluate cascading risks (with energy department); (iii) improve public health awareness of risks; and (iv) update heat-health plan (both with emergency management and energy departments).

**Partnership:** DOH is also designated one of several “partner” agencies in six activities under the “Neighborhood and Communities” thematic area: (i) identify ways to reduce energy poverty (with energy department in the lead); (ii) develop neighborhood vulnerability assessment; (iii) evaluate cooling centers and backup preparedness; and (iv) develop community preparedness “resilience hubs” (all with emergency management in the lead); (v) develop preparedness plans for back up food access; and (vi) encourage healthy lifestyles in built environment (both with office of planning in the lead).
city’s health department was reported to have leadership for heat-health planning; to work in partnership with emergency management and urban planning agencies on several preparedness activities; and to have both leadership and partnership roles on vulnerability-related assessment and actions [49].

We identified several major intervention strategies for each of the five activity areas, and grouped them by those directly relevant to population health (“people”); and those more indirectly linked to health via urban infrastructure (“assets”) (Table 2). Most health department engagement was associated with implementing strategies to reduce risks for people, while few examples of health department engagement were identified in association with strategies to reduce risks to assets.

### Discussion

In this analysis of the adaptation plans of 22 highly health-adaptive large cities, all city plans reported actions in two or more of five promising health-associated activity areas, with hazard and vulnerability mapping, extreme event preparedness and extreme heat plans being most common. Yet less than three-quarters of these highly health-oriented city plans referred to a public health agency as part of the climate planning effort. Health department engagement was mainly focused on specific strategies within extreme heat plans, with limited involvement in vulnerability mapping, some modest engagement with preparedness and response, and only nascent climate-health outcome surveillance efforts. The share of cities with engaged public health departments was notably higher in low- and middle-income cities, although our sample size was small. Overall, health was more often considered—and public health agency engagement more often occurred—within one of several thematic priorities (e.g., “neighborhoods,” “communities,” “public services”); in contrast, health and public health agencies were rarely integrated across climate plan priorities. This limited role for public health reflects a marked disconnect from the strong overarching health focus of the adaptation plans of these health-active cities, and stated plan goals.

When drilling down to understand the role of health departments reported in these 22 city adaptation plans we found differences across the five activity areas (Table 3):
A high share of our cities employed climate-related mapping; however, most focused primarily on hazard mapping, with fewer cities reporting vulnerability mapping. Public health agency engagement in mapping was modest, and numerous other agencies were involved, including weather and GIS services as well as urban planning. Among cities where public health engagement was strongest, we found more prevalent use of vulnerability indices and mapping, often within risk assessment and communication efforts.

We also found a high share of our cities reported extreme heat plans, the vast majority aiming to protect people from direct impacts of extreme heat. Public health agency engagement for this activity was the highest reported for any activity; however, it was often limited to heat warnings and risk communication. Health departments were typically not engaged as partners in the greening, urban design or other built-environment components of heat management; numerous other agencies were involved in these heat management strategies, in particular emergency response, utilities, and urban planning departments.

Nearly all cities reported preparedness and response interventions related to protecting people, often focused on community drills and first responder training; a majority of cities also reported infrastructure preparedness actions, often linked to cascading effects and indirect health impacts (such as “future-proofing” water, electricity, drainage and transport services; and coordinating “lifeline” utility arrangements in the aftermath of weather-related disasters). Public health engagement was modest however, and appeared largely oriented toward preparedness training for public health staff and risk communication. Numerous other agencies were reported to be engaged in preparedness and response strategies, notably weather services, emergency management agencies, urban planning departments, public utilities and other infrastructure providers.

A majority of cities reported some climate-health outcome surveillance and climate hazard and risk monitoring. Many of these reported general climate monitoring (e.g., hazard and exposure indicators as well as outcome and performance indicators). However only a small share of cities reported specific health outcome surveillance, with the most frequent outcomes being HRI and vector-borne diseases; this was mainly carried out by public health agencies. Most of this health outcome surveillance was reported by cities in low- and middle-income countries.
• A low share of cities reported other (non-heat) early warning, and most were focused on
one of two different types of hazards: landslides and flooding; or infectious disease. There
was little public health agency engagement reported, and when present it focused mainly on
infectious disease modeling toward development of early warning, often linked to surveil-
ance. There was little evidence of public health engagement in landslide or flood early
warning.

In summary, while most of the adaptation plans we reviewed reported some mapping, pre-
paredness and heat plan activities, public health agency involvement was focused mainly on
one activity: heat plans. And even then, public health engagement was fairly limited, not often
extending, for example, to supporting targeting of greening or cooling initiatives with health-
outcome and vulnerability data. The other activity where health departments represented the
majority of any reported agency engagement was climate-health outcome surveillance; how-
ever few cities reported carrying out this activity. We also found little evidence of health or
health departments being engaged across elements of the plans, suggesting there remain
important barriers (and lack of facilitators) to health integration into adaptation in a manner
consistent with its prominent place in adaptation plan goals.

Recent country-specific studies provide insights that help to interpret our findings, particu-
larly regarding factors that may facilitate or impede health department engagement in climate
adaptation. In the UK, local health authorities were found to have varying roles in climate
change adaptation often aligning with emergency planning, suggesting the potential for public
health to grow toward greater collaboration with preparedness and response agencies; barriers
to public health engagement were resource- and knowledge-based [9]. A study of Canadian
health adaptation across government levels found that though municipalities were adapting
autonomously independent of higher government-level action, efforts were at very early stages
[50]; subsequent research suggested that federal and regional governments could facilitate
local adaptation in multiple ways, e.g., by building local public health capacity, and supporting
and disseminating knowledge [36]. In the US, the federal-level Climate-Ready States and Cities
Program supported by the Centers for Disease Control and Prevention (CDC) was conceiv-
ed and implemented with this sort of national-level enabling in mind; however, reviews have doc-
umented barriers including resources and knowledge among others, though amid positive
results [39, 51]. Such barriers may affect even cities with substantial resources: a review of cli-
mate health resilience planning in New York City (not included in our study) concluded that
while this city is fortunate to have its own climate change research capacity (New York City
Panel on Climate Change), effective health-centered adaptation will require the city to enhance
and better integrate into adaptation planning its core public health surveillance functions,
including monitoring climate-related health outcomes such as morbidity due to HRI, floods
and storms, and allergies, among others [52]. It has been suggested that health department
engagement in urban climate planning may be in part driven by whether public health is man-
aged centrally or at city level; in our study, though the sample size was small, we did not find a
difference in share of health engagement in the five activities comparing adaptation plans
reporting city public health departments (the majority of cities) with those reporting higher
government health department engagement.

Further examining research gaps provides some additional insight into knowledge barriers.
For example, a large machine learning analysis of climate and health research confirms previ-
ous findings that association studies continue to dominate research with adaptation-related
research remaining “a niche area” [53]. Cities continue to lack knowledge of what works, rely-
ing instead on promising practices shared via networks, scaling-up bottom-up
experimentation and other strategies. Notably, there is no major global city climate network organized around population health outcomes and public health interventions. New initiatives such as the development of a searchable database of peer-reviewed studies in climate and health [54] may be helpful toward this end. Gaps in epidemiological research may also be an obstacle. A recent overview of systematic reviews pointed out that extreme weather exposures (heat and precipitation) and mortality and infectious disease outcomes receive the most research attention [55]; in contrast, our findings suggest cities are primarily concerned about heat-related morbidity (particularly HRI), impacts of extreme events on injury, displacement and loss-associated mental health, effects of drought on nutrition and infectious disease, and of temperature and extreme events on mental health. To be most useful to city decision-makers, climate-health association studies may need to focus on a wider range of exposures and outcomes. Epidemiological research more directly relevant for city health departments may also help to better equip them to address longer-term risks, generally not addressed in the plans we examined. For example, a review of studies on climate change and urban health in China noted that insufficient attention to health implications of sea-level rise was a critical gap in the literature [56].

Heat-health plans warrant particular mention because of their predominant role and high public health participation in this city sample. A recent review of health risks of heat extremes makes clear that these events are becoming “permanent features of summer seasons worldwide,” particularly in tropical regions and with notable risks for urban areas; authors suggest resources, research and risk communication efforts are needed [26]. Recent guidance from the WHO regarding European heat-health plans suggests that while there is insufficient evidence to recommend best practice governance arrangements, their integration within climate planning appears more robust than their integration within health and disaster planning, and closer coordination with local health agencies and additional resources will be essential for both efficiency and effectiveness [25]. Our findings are suggestive that health-active cities may already be including public health more fully in heat-health action plans, but that this inclusion needs to be more ambitious.

While our study design has several strengths—including facilitating structured comparison across health-engaged cities and focusing on the under-examined role of city public health agencies—it also has limitations. We reviewed publicly-available plans without additional information from city authorities, and examined reported intentions rather than actual actions. On the other hand, many activities actually carried out were likely not reported in adaptation plans; for example, San Francisco’s heat vulnerability index and mapping, developed by the city public health department and expanded to other climate hazards, was not included in the most recent version of its climate adaptation plan and would have changed our reporting [57]. Thus, our findings inevitably will have gaps and inaccuracies, and should be seen as indicative of trends. Our initial city pool was a non-representative convenience sample of cities reporting to CDP, from which we purposefully selected highly health-engaged cities. Our findings therefore cannot be interpreted as generalizable to the group of all large world cities; on the contrary, we would expect our findings to represent the high end of involvement in the five activity areas examined, and public health engagement. In addition, incomplete reporting of the engagement of implementing agencies hampered our analysis; we have presented public health agency engagement as a share of all agencies reported to help respond to this limitation. Due to inevitable inconsistencies in defining an “action” across cities, we did not attempt to quantify the number of actions cities reported in each activity area. Jurisdictions of all sizes around the world from rural settlements and villages to mega-cities are subject to climate hazards. Our focus on this group of large world cities is not intended to suggest jurisdictions of other sizes are not at risk, or carrying out important health adaptation. In particular, medium-
sized cities (e.g., population between 100,000 and one million) are the urban group growing fastest and may be both at greater risk for some hazards as well as have greater impetus and space for adaptive measures. Our results are not likely generalizable to other jurisdictions, though may provide some background for needed work examining their adaptation plans.

An important limitation of our study was lack of data availability for cities in low- and middle-income countries, for which adaptation research lags behind that of high-income countries [58]. Our study design relied on selecting large health-active cities from the CDP database, the most comprehensive and consistent publicly-available database of adaptation; yet CDP’s database is skewed toward high-income countries. Furthermore, for some low- and middle-income cities we did not locate adaptation plans. In particular, the United States was over-represented and many other regions were under-represented. The small number of cities from Asia is of particular concern given its large and growing urban population and the stark vulnerability to climate-related hazards of many geographic locations in the region [59]. Of concern also is low representation of cities from Africa, where a recent review found only 5% of adaptation actions had taken place in cities [60]. Intriguingly, in this study we found that adaptation plans of cities in the low- or middle-income group reported a higher average number of health-associated activity areas compared with those in high-income countries (4.2 vs. 3.4 activity areas per city), a higher average number of activity areas with public health agency engagement (2.5 vs. 1.9 activity areas per city), and a larger share of public health engagement in adaptation plan activities generally (83% vs. 69%). However, our sample size was small.

We did find that several cities have begun meaningful integration of public health agencies across climate plans and priorities, among them Barcelona, Baltimore and San Francisco. A new initiative for climate-health monitoring and surveillance coordinated by the Barcelona Public Health Agency and being incorporated into the city climate adaptation plan [44] shows a promising path forward for health surveillance to guide adaptation planning which may be useful for other cities. In addition, Barcelona’s climate plan has been analyzed from the public health point of view demonstrating how cross-cutting governance relationships have been achieved in practice, for example between public health and water authorities on water availability, and between public health and urban planning on extreme heat management [61]. Recent research examining two large cities not included in our sample, New York City and Rotterdam, similarly suggests progress in this direction toward “an integrated, experimental and inclusive approach to climate governance” that crosses multiple sectors including health, transport, and energy, and that facilitates innovation [62]. Other researchers have recently proposed wider dialogue on ways to help decision-makers “think strategically about layering adaptation solutions” across technological, nature-based and social domains, so as to take advantage of synergies and move toward more transformative outcomes. While our study adds to the body of literature suggesting that health engagement in city adaptive action remains insufficient and primarily reactive, we also found suggestive evidence that forward-thinking cities are beginning to experiment with such synergistic integration in the context of health. These efforts at cross-sectoral collaboration and experimentation are more likely to lead to truly transformative climate governance [6].

The IPCC’s Sixth Assessment Report warns that every world region is expected to see growing climate-related hazards and population risks in the near term, including particular risks for cities [4]. Already, the world’s 150 largest cities have seen more than a five-fold increase in extreme heat and extreme precipitation events; continued urbanization will exacerbate vulnerabilities, mainly in low and middle-income countries, making initiatives such as extreme event early warning less an option than a necessity [3, 23]. Meanwhile, health departments will continue to come under increasing pressure as near-term hazards such as extreme heat and extreme precipitation and storms continue to affect urban populations, including as
compound simultaneous events with cascading impacts. The IPCC also warns that many cli-

cimate hazards are likely irreversible on human generational timescales. Cities will thus increas-
ingly need to balance short-term concerns with a growing focus on preparedness for slow-
onset hazards such as drought and sea-level rise, and the societal disruptions they bring. We 

found only limited evidence that cities were addressing these longer-term risks to health.

Conclusions

Public health integration in urban climate adaptation planning remains more a goal than a 

reality; even highly health-adaptive large cities report fairly modest public health engagement 

in climate adaptation plans, and very few seem to have integrated a health perspective across 

thematic or sectoral climate adaptation priorities. In our sample, public health agency engage-

ment was highest in heat planning and climate-health surveillance; heat planning activities 

were prevalent across this group of cities, while climate-health surveillance activities were 

much scarcer. We also found that multiple agencies are reportedly engaged in implementing 

health-associated activities proposed in city climate adaptation plans, in particular planning, 

environment, emergency management and response, weather services and utility and infra-

structure agencies; ideally, public health could identify ways to proactively engage with these 

agencies [63]. Our findings suggest several climate-health governance opportunities could 

improve large city adaptation outcomes:

1. Scaling up public health climate surveillance to guide and target adaptation plan goals and 

evaluation of success; though this is beginning (e.g., Barcelona; New York City) it is not yet 

optimized even in highly health-adaptive cities;

2. Expanding public health engagement more robustly into vulnerability mapping (in collabora-

tion with urban planning, weather services, communication); there are indications that 

highly health-adaptive cities (e.g., San Francisco) have begun to do this;

3. Mainstreaming heat action planning across global cities particularly in the tropics, based on 

emerging best practice that prioritizes closer integration of local health agencies, particu-

larly regarding heat early warning alerts; and scaling up multi-hazard early warning (e.g., 

Rio de Janeiro).

4. Enhancing city public health engagement in preparedness, in partnership with emergency 

management and response departments (e.g., "resilience hubs") and utilities (e.g., "lifeline" 

utility planning); evidence suggests health-adaptive cities have begun to do this (e.g., Balti-

more, Washington DC);

5. Identifying barriers and facilitators of city health department integration into climate adap-

tation planning, including resources and training, and aligning urban climate-health 

research with cities’ actual adaptation-related information needs; and

6. Enhancing focus on under-represented cities in low- and middle-income countries, in par-

icular Africa, Latin America and Asia; our limited evidence in cities in these regions is sug-

uggestive of greater public health engagement in adaptation, and pursuing lessons may be 

more widely useful. Similarly, greater attention on small and medium-sized cities, where 

much population growth is centered, is also warranted.

Yet we also found evidence of important climate-health action and even innovation in the 

22 cities we examined; cities remain incredibly promising partners in achieving health-sup-

portive climate adaptation, as they are leaders in the imperative of climate mitigation. But city 

health departments are under-resourced and health is among the lowest areas of urban sectoral
spending on adaptation [64]. The Covid-19 pandemic has compounded the stresses on health departments worldwide. The new WHO strategy for planetary health puts “health at the heart” of urban planning, noting that cities have governance structures that can facilitate the types of integrated solutions needed for synergistic efficiency and effectiveness of adaptation, such as through Mayor’s office or city councils [65]. Initiatives like the WHO European Healthy Cities Network demonstrate an approach for collaborating to respond with greater strength and preparedness to global emergencies, including the Covid-19 pandemic and climate change [66]. Our findings support enabling health at the heart of urban climate efforts by engaging city health agencies more fully in climate adaptation.

Supporting information

S1 Table. Key features of city climate adaptation plans for 22 highly health-adaptive large world cities. (DOCX)

S2 Table. Public health agencies engaged in five health-associated climate adaptation activities as reported by 22 large highly health-adaptive cities. (DOCX)

S3 Table. Public health engagement spectrum: Five health-associated activity areas reported in climate adaptation plans of 22 highly health-adaptive large cities, by number of activities areas with health department engagement. (DOCX)

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