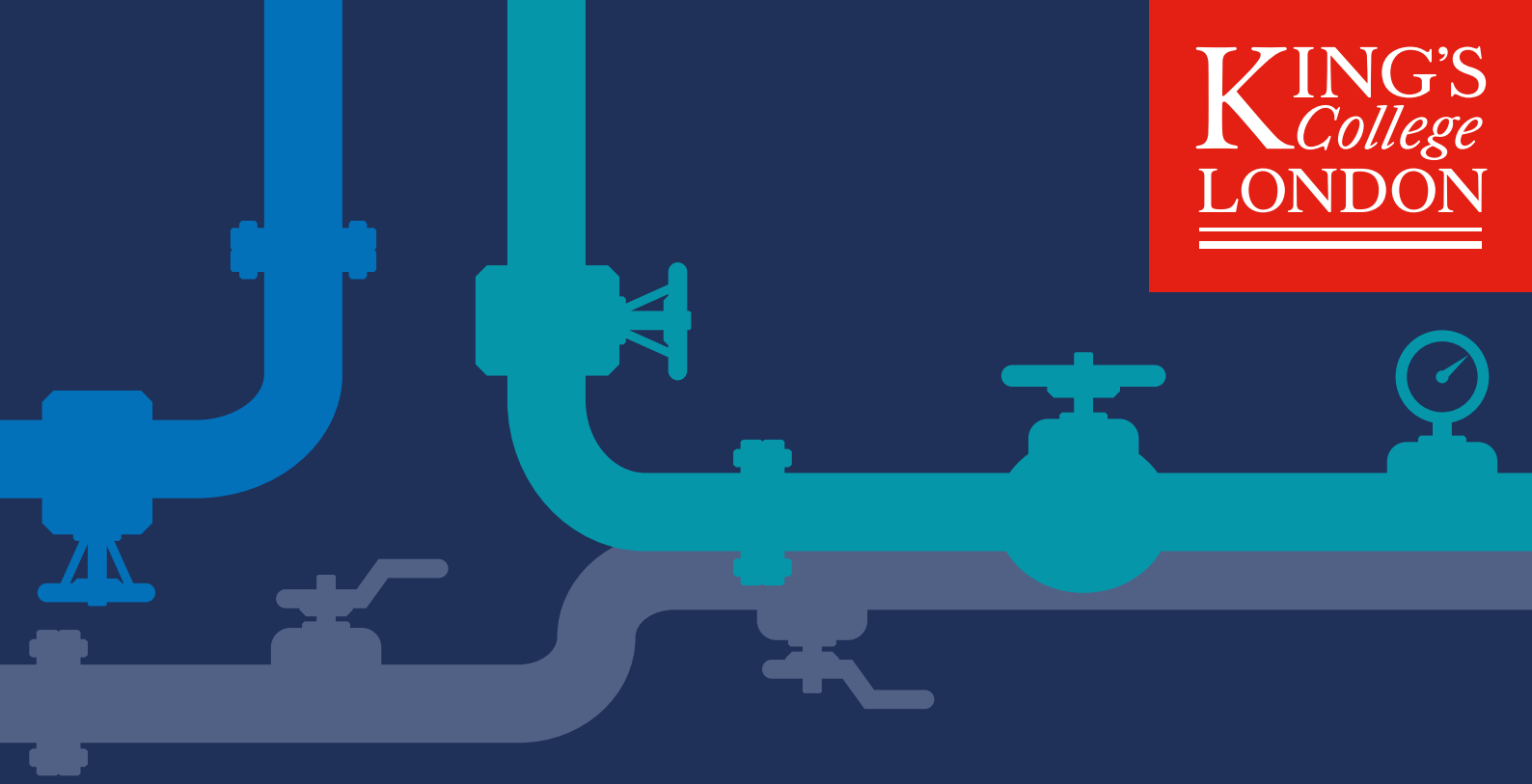

Plumbing poverty in US cities:

A report on gaps and trends in household water access, 2000 to 2017

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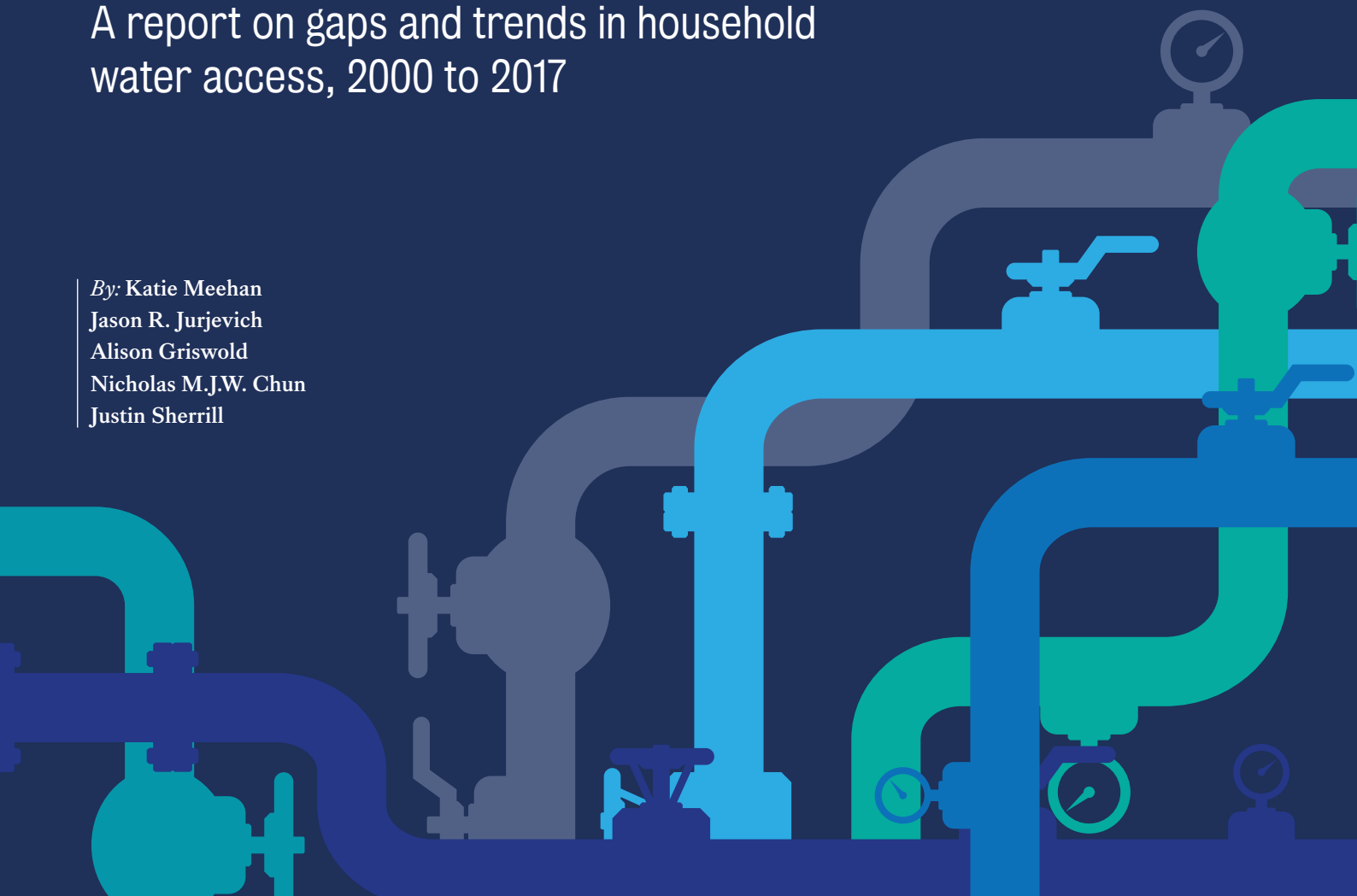

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Executive summary

What would you do without running water in your home?

Many, possibly most of us, have never needed to consider this. We take for granted the clean water that flows from our taps and fills our showers, baths, and toilets. Piped water access is fundamental to a thriving life – to social, economic, and environmental wellbeing. This is especially true 20 months into a global pandemic in which one of the most basic and enduring public health recommendations has been to wash our hands well and often.

Worldwide, an estimated 2 billion people, or 26% of the global population, lack safely managed drinking water services and 3.6 billion (46%) do not have safe access to sanitation. Where do you picture these unplumbed populations? It might be surprising to learn that more than 1 million people with incomplete plumbing live in the United States, the majority in major metropolitan areas.

In 2017, nearly 460,000 US households – some 1.1 million people, enough to fill a large city – lacked piped running water in their homes. We call this state 'plumbing poverty.' Our research documents emerging trends and persistent gaps in urban water access over the past 20 years, before and after the Great Recession of 2008. Focusing on 15 major metropolitan areas and drawing on analysis of nearly two decades (2000-2017) of Census data, we identify racialized disparities in household water access, compare trends between cities and over time, and point to worsening conditions for urban dwellers, especially renters. Plumbing poverty is a social, not technical problem, with roots in unaffordable housing conditions, widening wealth gaps, and spatial inequality in some of the fastest-growing US metros. While some cities have managed to decrease their unplumbed populations over the past two decades, others have made no progress or, worse, seen alarming jumps in the share of people living without piped water access. Many of the worst offenders in terms of plumbing poverty – such as San Francisco, California – are also some of the wealthiest American cities.

Plenty of research addresses household water insecurity in the global South. This report aims to understand problems of infrastructural injustice in the places where many would least expect: cities in the United States.

Introduction

It took a global pandemic for some homes in Detroit, Michigan, to get running water again.

Since 2013, at least 140,000 Detroit water accounts – including homes and residences – have had their water service shut off for unpaid bills under a city debt recollection program.[1] Thousands were without water as of January 2020, when US officials confirmed the nation's first case of Covid-19. As fear and panic gripped the country, public health and government officials had little advice to offer other than frequent and thorough handwashing.[2] But how do you wash your hands without running water? Faced with a once-in-a-century global health emergency, Detroit relented, announcing plans to halt shut-offs and temporarily reactivate water services for disconnected residents.

Detroit's punitive water shut-offs, and the water poisoning crisis in Flint, Michigan, have moved deindustrialized, poor, and predominantly Black cities to the center of recent conversations on the water and infrastructure crisis in the United States.[3] Flint, for example, has become a prominent symbol of citizen struggles for safe water and the fight against racialized and class-based environmental injustices.[4] For every Detroit or Flint, however, another US city struggling with unequal water access has quietly slipped under the radar.

In this report, we put a spotlight on those cities. Nearly 460,000 US households, or some 1.1 million people, lacked piped running water in their homes between 2013 and 2017.[5] Let us say that again: in the modern age, there are enough Americans living without piped water – a condition that we call *plumbing poverty* (Box 1) – to fill San Antonio, Texas, the nation's seventh-largest city.

Most unplumbed Americans live in cities (73%). As our report explains, metros such as New York, Los Angeles, and San Francisco top the plumbing poverty list in absolute and relative numbers of people without piped water (Table 2). Digging into the data, we find that renters, households of color (particularly Black and Indigenous households), and people living in areas of widening income inequality lack plumbed connections to exceptional degrees. Perhaps most alarming, our research reveals a set of boomtown cities, such as Phoenix, that have stalled or stagnated in terms of connecting households to the grid. A select group of cities now count *more* unplumbed households than two decades ago. In Portland, Oregon, despite its reputation as a hip city where 'young people go to retire,'[6] plumbing poverty has in fact increased since 2000, as the implications of tech capitalism, skyrocketing rents, and racialized housing disparities force people into even more precarious living situations.

Safe and secure water access is foundational to a thriving life.[7] And yet, less is known about piped water access and trends in countries like the United States, where we assume water service is universal, especially in major cities.[8] This white paper presents new research on the state of plumbing poverty in US cities. Focusing on 15 major metropolitan areas and drawing on analysis of nearly two decades (2000-2017) of Census data, we identify persistent disparities in household water access, compare trends between cities and over time, and point to worsening conditions for urban dwellers in some of the wealthiest metros.

PHOTO: SHUTTERSTOCK/ JOHN BOZICK

Detroit, Michigan. July 2019. Clean water is still a demand in Detroit, evidenced by demonstrators during the 2020 presidential debates at the Fox Theater.

Box 1: Definitions

American Community Survey (ACS): a yearly survey by the US Census Bureau that collects important information about household demographics, livelihoods, and housing conditions. The ACS compliments the decennial Census, which is administered every 10 years. Both are important sources of household plumbing data (see Box 2).

Household: a household is a person or group of people who live together and share resources in the same dwelling unit. A household is distinct from the less inclusive category of family: for example, students sharing an apartment are a household, even if they are not related by blood. Importantly, anthropologists and geographers define a household as a social living and resource sharing unit and not a physical structure (i.e., a house).[12] For this reason, people experiencing homelessness also live in households, even if they lack a stable or conventional shelter. However, the Bureau does not ask people in homeless shelters about piped running water access. For nuances in Census household data as it relates to homeless populations, see Annex A.

Metropolitan Area: a metropolitan statistical area (MSA) is a county-defined geographic region containing a densely populated core urban area of at least 50,000 inhabitants and neighboring counties with close economic and social ties, as defined by the US Office of Management and Budget.[13] In this report, we use the terms 'city' and 'metro area' interchangeably; in geographic terms, we are referring to an MSA.

Plumbing Poverty: a condition describing households that lack running water, an indoor bathtub or shower, or flush toilet (where toilet data are available, see Box 2).[14] In this report, we use the phrases 'plumbing poverty,' 'unplumbed,' and 'incomplete plumbing' interchangeably. Crucially, plumbing poverty is about water access and is therefore just one slice of *household water insecurity,* a broader term that extends beyond access to include water quality, reliability, and affordability (see Box 3).

We ask:

- Who (and where) are unplumbed urban Americans?
- Which cities have high rates of plumbing poverty?
- What patterns might we discern across and between cities?
- What does the future hold for urban plumbing poverty?

In answering these questions, our study provides insight to future trajectories for US cities and spotlights human rights concerns that policymakers need to tackle with urgency. Given the proposed $1.2 trillion Infrastructure Framework – an ambitious federal plan to modernize and transform infrastructure across the United States – our research highlights an urgent basic need to federally subsidize and support the extension of piped water networks to unplumbed households, as part of the Biden Administration's promise to improve clean water infrastructure.

This report is part of the Plumbing Poverty Project, a research initiative directed by Dr. Katie Meehan of King's College London, in partnership with collaborators from the University of Arizona. Unlike most water insecurity research, which tends to focus on developing countries in the global South, our work aims to understand problems of infrastructural justice in the places we may least expect: high-income countries like the United States.

In this report, we explain plumbing poverty and track its progress in 15 select US metros from 2000 to 2017.[9] In a large country like the United States, cities and their development pathways are diverse, so we present a deeper investigation into three metros – San Francisco, Phoenix, and Milwaukee – that, together, provide a range of contexts and trajectories of urban water insecurity over the past two decades. We conclude with policy recommendations for improving household water access in the United States.

Safe and secure water provision is a basic human right. Without safe, reliable, and affordable water, unplumbed households must work more, not less, to access the same personal and social benefits of water that networked society already enjoys.[10] The 1.1 million Americans who lack piped running water in their homes struggle daily to wash their hands, use the toilet, bathe, cook, wash, and do anything else that clean and reliable water access facilitates. A lack of water produces stress, anxiety, and poor mental and physical health outcomes.[11] The surprising prevalence of unplumbed households in many US cities – well beyond the Flint water crisis – underscores the urgency of our project to better understand household water insecurity in the United States, itself just one understudied piece of the global infrastructure puzzle.

Plumbing poverty is a problem in cities

PHOTO: ISTOCKPHOTO.COM/LEONID ANDRONOV

Suburban area near Detroit, USA

Plumbing poverty in the United States is often thought of as a rural problem – families in Appalachia who haul their weekly drinking water supply by pickup truck to homes off the plumbing grid – but the reality is that unplumbed households are all too common in cities. Across the United States, 73% of households without piped water are in metro areas and nearly half (47% or an estimated 514,000 people, a population the size of Sacramento, California) are in the 50 largest metros. Out of this total, 29% of unplumbed households are in the 15 metros profiled in this report.

In most US cities, water and sewerage are delivered by a municipal utility or community service provider, which could be public or privately owned and operated. From the provider's perspective, the municipal plumbing responsibility tends to stop at the sidewalk, leaving the homeowner responsible for coming up with the funds to connect individual homes to the network. Costs of connection can be very expensive, adding up to thousands of dollars to cover the permits, fees, contractor labor, and infrastructure costs associated with connecting users to the system (see Table 1).

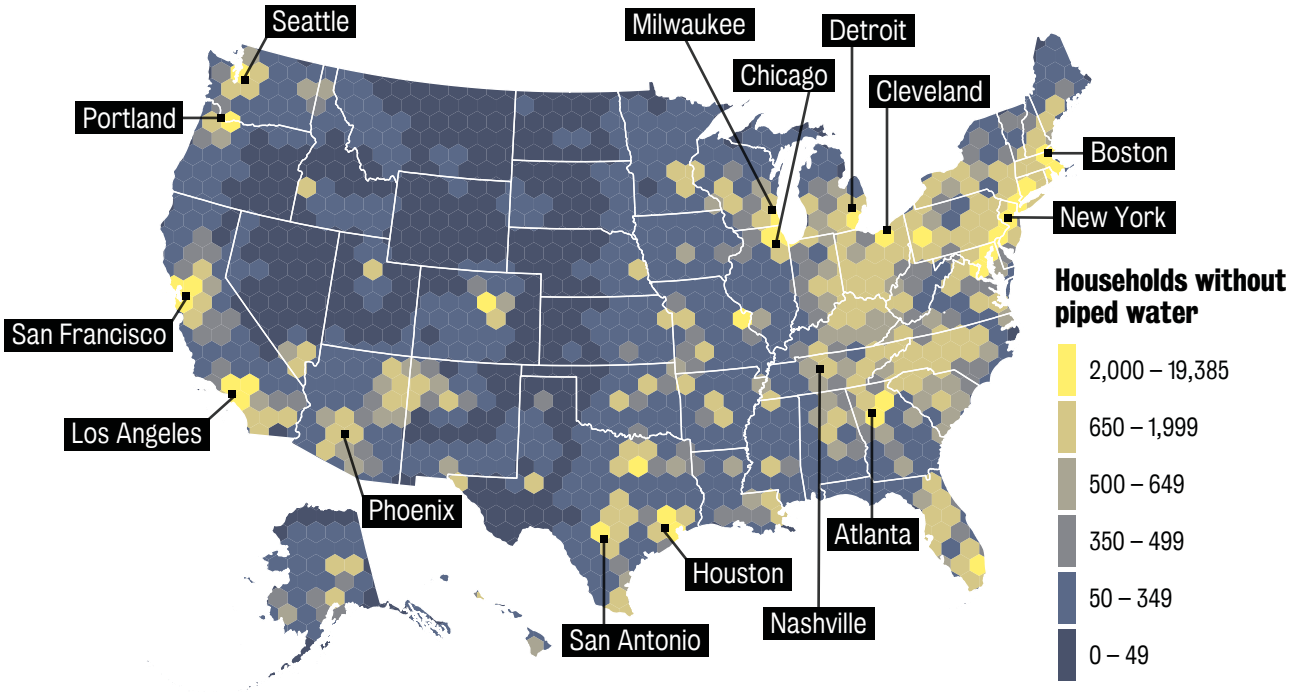
Such costs are prohibitive for low-income households, impossible for renters who lack legal title to modify the building/property, and difficult for local water utilities and housing agencies to monitor, coordinate, and finance. To overcome these challenges, governments have historically stepped in with large infrastructure spending packages to finance water supply (and treatment) systems and to subsidize household connections to the grid. One of the last major federal government-sponsored expansions of the water network occurred during the 1930s New Deal. The Public Works Administration financed between 2,400 and 2,600 water projects, to the tune of $312 million (half of the government's waterworks budget) and mostly in rural communities with less than 1,000 people.[15]

Fast-forward to today, and our analysis reveals the unmistakable urban nature of plumbing poverty. Figure 1 illustrates the geographic distribution of plumbing poverty across the United States: lighter shades (in yellow) depict higher numbers of unplumbed households. Plumbing poverty is most common in the nation's largest cities, where most Americans live.

Notable hotspots include New York, where 65,000 residents live without piped water, followed by the major West Coast metros of Los Angeles and San Francisco, where 44,200 and 27,400 people lack piped water, respectively. These three metros rank first, second, and third, respectively, for the highest number of residents with incomplete plumbing. Smaller but significant plumbing poverty exists in the Rust Belt cities of Chicago (22,300 people) and Detroit (11,600 people). Some of the highest rates of plumbing poverty are in Sun Belt cities (Figure 1). For instance, 14 of the 19 largest metros with above-average rates of urban plumbing poverty (0.3%) in 2017 were in the Sun Belt.[16]

FIGURE 1: **Households without piped water in the United States, 2013–2017**

Lighter shades (in yellow) depict higher numbers of unplumbed households, with notable concentrations in West Coast cities, the urbanized Eastern seaboard, and cities in the Rust Belt and Sun Belt.



Data source: US Census Bureau. Base map: Meehan et al (2020)

TABLE 1: **A Sample of Water Service Fees in the City of Tucson, Arizona**

Water Service Turn-on Charge	$22.69
New Service Installation Cancellation Fee	$25.56
Returnee Check (Insufficient Funds) Service Charge	$28.00
Delinquent Service Change: Customer Notice	$11.25
Delinquent Service Charge: Water Meter Lock	$55.52
Tampering Fee: Turning on water without authority	$101.48
Main Extensions for Water Service:	Contractor cost plus $317.00 Administrative Fee
Deposit: Contractor use of Tucson Water construction water meter	$1,762.00

> Notable hotspots include New York, where 65,000 residents live without piped water, followed by the major West Coast metros of Los Angeles and San Francisco, where 44,200 and 27,400 people lack piped water, respectively

The global context

Safe and secure access to water and sanitation is a recognized human right, first declared in the 1992 Dublin Principles on water management and reaffirmed in the 2010 UN Human Right to Water and Sanitation (Resolution 64/292). The United States and 40 other countries abstained from Resolution 64/292, arguing that the right to water is already crystallized into customary international law. A total of 122 countries voted for the resolution and none voted against.[17]

Nonetheless, many governments have adopted a human-rights based approach to water through law and constitutional reforms, regulatory changes, and judicial decisions.[18] In 2012, Mexico amended its national constitution to recognize the right of all people, regardless of national origin, to safe, affordable, and reliable domestic access to water and sanitation.[19] Mexico's policy was widely viewed as a milestone in promoting a human-rights approach to water governance, coming on the heels of similar constitutional reforms in Bolivia, Chile, and Uruguay.

In 2012, California became the first US state to formally recognize the human right to water when it passed a bill (AB 685) charging all relevant state agencies to 'consider' the human right to water in executing policy, programming, and budgetary activities.[20] Neither the federal government nor any other state has adopted a similar measure, making water policy progress a loose patchwork of state and local initiatives.

How does piped water access in the United States compare with its global peers? To date, research on insecure water access has largely focused on the global South, rather than high-income European countries and similar nations across the global North. As of 2020, the United Nations estimates that 2 billion people worldwide or 26% of the global population lacked safely managed drinking water services; 3.6 billion (46%) were without safe sanitation services; and 2.3 billion (29%) did not have a basic hand-washing facility with soap and water at home.[21] The UN has said the world is not on track to achieve Sustainable Development Goal 6, the goal of water and sanitation for all by 2030.[22]

Box 2: The plumbing question: measuring piped water

Since 1940, the US Census Bureau has collected data on household piped water access. The plumbing question offers the best and most detailed picture of water access at the household level in the United States and is widely used by federal, state, and local government agencies as an indicator of housing quality and environmental health. The Department of Housing and Urban Development, for example, uses the plumbing question to help identify 'substandard' housing units.[23]

Categories and definitions of 'complete plumbing' – that is, the absence of plumbing poverty – have changed over time, reflecting the evolution of housing development and infrastructure in the United States (IPUMS). The US Census Bureau currently defines complete plumbing as the presence of hot and cold running water and an indoor bathtub or shower, all located within the same housing unit (Figure 2).

Prior to 2016, the Bureau also included an indoor flush toilet in its definition of complete plumbing. Starting in the early 2010s, Congressional Republicans began to target the American Community Survey, arguing that it was 'unnecessary and completely unwarranted government intrusion.'[24] Following a review in 2015, the Census dropped the toilet box from the plumbing question, wiping 43,000 US households or an estimated 106,000 people from the data on plumbing poverty.

Box 3: Household water security is more than access

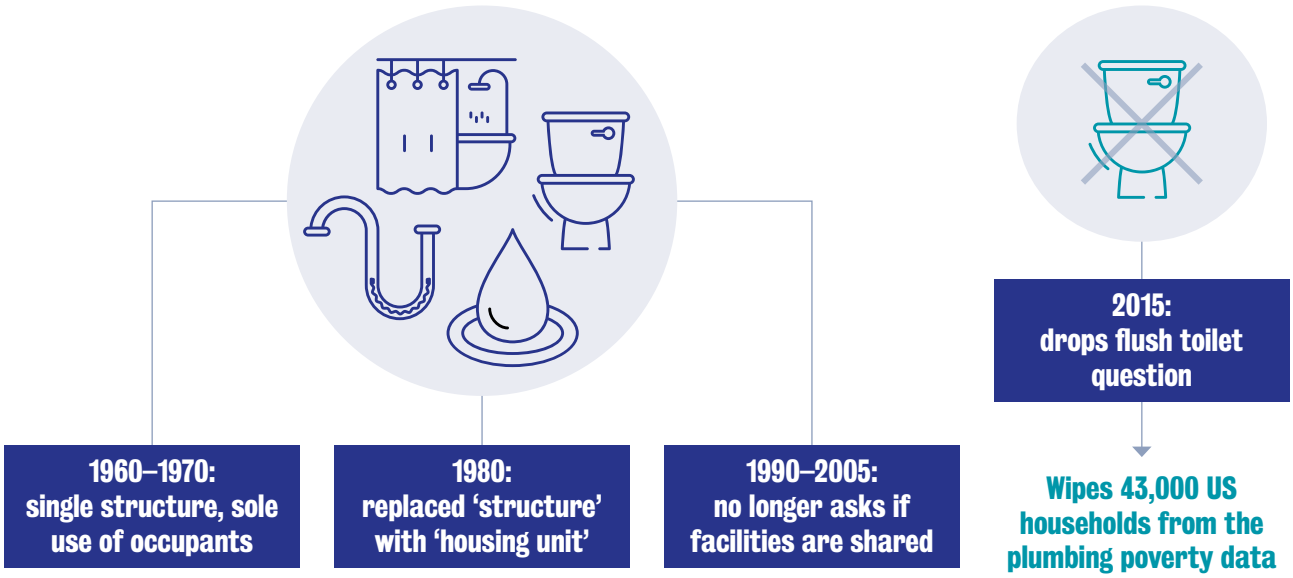
Water is vital to a thriving life and economic, environmental, and social well-being. While our analysis in this report focuses on piped water access, we recognize that *household water security* is about more than piped connections. Experts define household water security as the safe, affordable, and reliable access to sufficient quantity *and* quality of water for household consumption, production, and cleanliness,[25] a definition that includes critical water considerations beyond access and plumbing.

Measuring these other key ingredients is beyond the scope of this report, but important to understand the full context. For more information, see work by researchers in the Household Water Insecurity Experiences Research Network (HWISE), who have collectively published more than 100 articles on the social and environmental drivers, dimensions, and human health implications of household water in/security.

FIGURE 2: **Evolution of the 'plumbing question' in the US Census**

Date	Definition of 'complete plumbing facilities'
1960–1970	Piped hot and cold water, flush toilet, and bathtub or shower, all within the structure and used only by occupants of that housing unit
1980	Changes location of facilities from 'structure' to 'housing unit'
1990–2005	Drops inquiry about whether facilities are shared
2016	Drops flush toilet from complete plumbing facilities

Table: Meehan at al • Source IPUMS • Created with Datawrapper



Findings

In some cities, plumbing poverty is getting worse, not better

Many people are aware of the piped water problems and poor infrastructure access in deindustrialized, cash-strapped Rust Belt cities like Detroit and Flint, Michigan. But they might be surprised to learn that our research finds some of the worst rates of plumbing poverty exist in some of the most affluent US cities. Table 1 presents the 15 US metro areas with the highest absolute number of unplumbed households and inhabitants. Metros are ranked in descending order, according to total number of unplumbed households in 2017 and alongside comparative data from 2000.

Among the 50 largest US metros in 2017, San Francisco had the highest share of unplumbed households (0.9%, +/- 0.1%), followed by Portland (Oregon), Milwaukee, San Antonio, and Austin. In terms of total numbers, the New York metro area was home to the most people without piped water access (65,000, +/-5,100), followed by Los Angeles (44,200, +/- 4,400) and San Francisco (27,400, +/- 3,300).

Plumbing poverty is improving in some cities, getting worse in others, and stagnating in still others. In Figure 3, we highlight changes in plumbing poverty in 15 metros between 2000 and 2017. (Plumbing poverty for the three metros shown at the top of Figure 3 – New York, San Francisco, and Los Angeles – is reported on a different scale because they have significantly larger numbers of households without piped water access.) Here, we see evidence of three trajectories of plumbing poverty in the United States:

1. The good news first: Many cities reduced plumbing poverty. Across the 15 metro areas with the highest absolute number of unplumbed households between 2013 and 2017 (Table 1), there were 8,700 fewer plumbing poor households in these metro areas in 2017 compared to 2000, a 39% decrease. New York City and Los Angeles saw the biggest absolute drops in plumbing poverty, while Detroit, Atlanta, Boston, Houston, and Chicago also registered declines.

2. San Francisco and Portland are prime examples of worsening trends. Plumbing poverty increased in both San Francisco and Portland by 1,600 households between 2000 and 2017, relative increases of 12% and 50%, respectively.

3. In other cities, plumbing poverty stagnated. The numbers of unplumbed households experienced little to no change in Milwaukee, San Antonio, Phoenix, Nashville, Seattle, and Cleveland. We view no change in plumbing poverty as equivalent to no progress. Stagnation ought to be taken as a wakeup call to leaders in these cities to prioritize policies focused on infrastructural equity and provision for all households.

PHOTO: STOCK.ADOBE.COM/TIM

Aerial view of the North Stack Interchange in Phoenix, Arizona

TABLE 2: **Plumbing poverty in select US metros, 2000–2017**

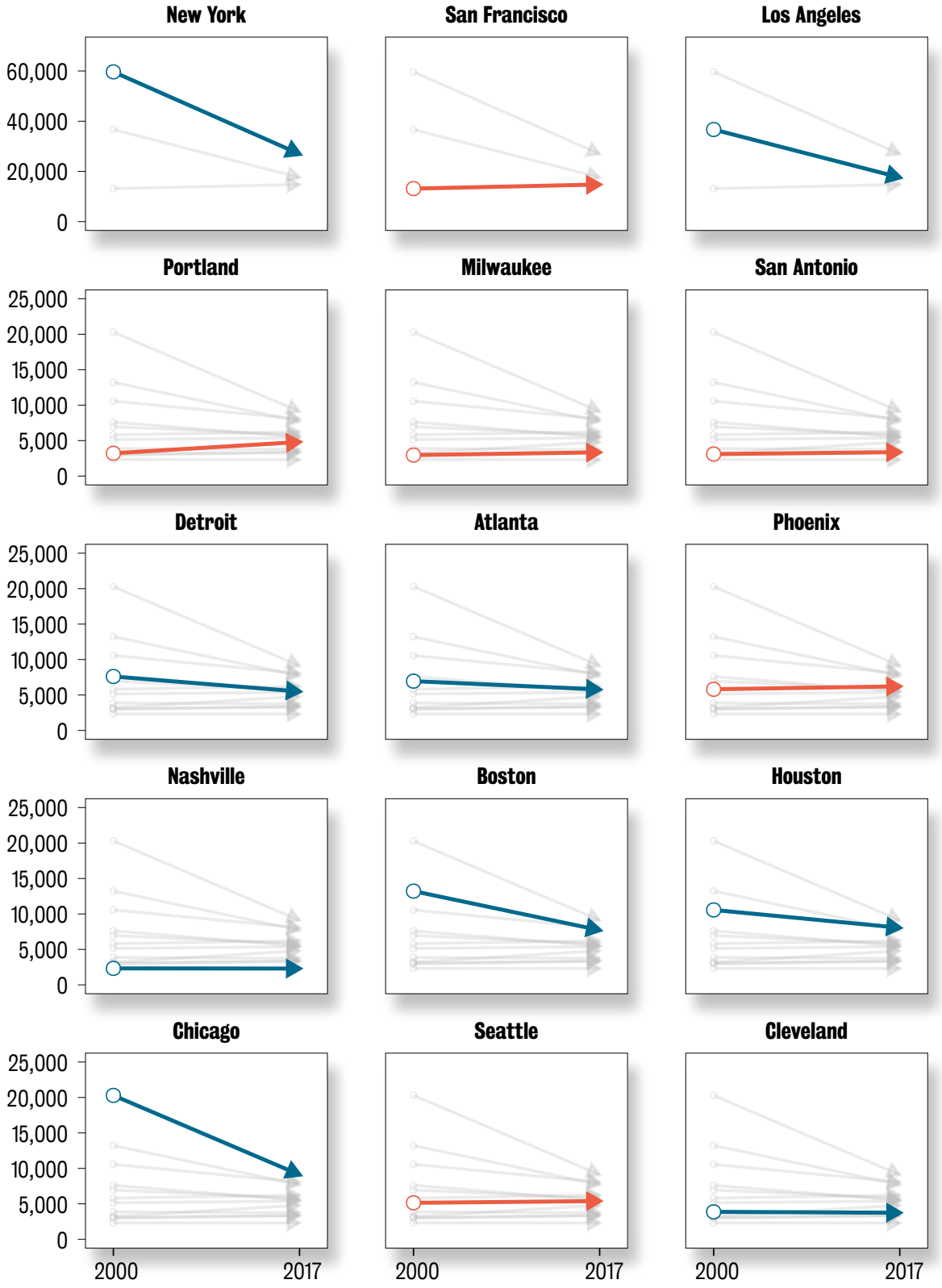
		2000	2013–2017	Statistically Significant Change	2000	2013–2017	Statistically Significant Change	2000	2013–2017
Rank	**Metro Area**	**Number of Households**			**Number of People**			**Share of Metro**	
1	New York, NY	59,700	26,900	* (-)	158,000	65,000	* (-)	0.90%	0.40%
2	Los Angeles, CA	36,700	17,600	* (-)	128,900	44,200	* (-)	0.90%	0.40%
3	San Francisco, CA	13,200	14,800	* (+)	30,200	27,400		0.80%	0.90%
4	Chicago, IL	20,300	9,100	* (-)	63,500	22,300	* (-)	0.60%	0.30%
5	Houston, TX	10,600	8,100	* (-)	33,000	20,300	* (-)	0.60%	0.40%
6	Boston, MA	13,200	7,700	* (-)	34,500	14,800	* (-)	0.70%	0.40%
7	Miami, FL	12,400	7,200	* (-)	34,500	18,900	* (-)	0.60%	0.30%
8	Dallas, TX	9,600	6,700	* (-)	28,300	16,400	* (-)	0.50%	0.30%
9	Phoenix, AZ	5,800	6,200		17,800	16,400		0.50%	0.40%
10	Philadelphia, PA	9,100	6,100	* (-)	24,700	13,500	* (-)	0.40%	0.30%
11	Atlanta, GA	7,000	5,800	* (-)	19,800	16,600	* (-)	0.40%	0.30%
12	Detroit, MI	7,600	5,500	* (-)	20,100	11,600	* (-)	0.40%	0.30%
13	Seattle, WA	5,100	5,400		11,800	9,800		0.40%	0.40%
14	Washington, DC	8,500	5,300	* (-)	23,400	14,900	* (-)	0.50%	0.20%
15	Portland, OR	3,200	4,800	* (+)	6,200	10,100	* (+)	0.50%	0.60%
Total for Top 15 Metros		**224,000**	**137,200**		**636,700**	**322,200**			

Metros are ranked (in descending order) according to total number of unplumbed households in 2017 and displayed with comparative data from 2000. We discuss changes between these metros and time periods in more depth in the Findings section. Estimates contain accompanying margin of error statistics, which are reported indirectly through statistically significant change (indicated with an asterisk) at the 90% confidence level.

Data source: Calculated by authors using data from the US Census Bureau

FIGURE 3: **In some cities, plumbing poverty is getting worse, not better**

Here we show the change in numbers of households without piped water in a snapshot of US metros from 2000 to 2017. Plumbing poverty is improving in some cities, getting worse in others (depicted in red), and stagnating in others. In Phoenix, for example, the number of unplumbed households rose from 5,800 in 2000 to 6,200 by 2017, an increase of 7%. Other metros stagnated, including Milwaukee, San Antonio, Nashville, Seattle, and Cleveland.



Source: Visualized by authors using data from the US Census Bureau

Figure 4 depicts the top 15 metro 'worst offenders' in 2017 by share (%) of population without piped water, and illustrates their corresponding rank in 2000, prior to the Great Recession of 2008. A higher rank indicates relatively worse plumbing conditions; this is a ranking that metros do not want to win.

As of 2017, San Francisco had the highest share of unplumbed households in the 50 largest US metros, followed by Portland, Milwaukee, San Antonio, and Austin, in respective order (Figure 4). Meanwhile, Los Angeles, which had the worst share of plumbing poverty in 2000, dropped to seventh place in 2017, while New York improved from second to 10th.

Some cities fell in the rankings, indicating moderate improvements but still high numbers of unplumbed households. Metros such as Memphis, New Orleans, and Houston fell a few spots from 2000 to 2017. Nonetheless, their 'gains' in terms of household water access are minimal. For example, unplumbed households in Houston decreased by just 2,500 over this time period, from 10,600 (0.6% of metro population) in 2000 to 8,100 (0.4%) in 2017. In absolute terms, Houston has the fifth-most households without running water among US metros.

Most alarming are the metros where plumbing poverty sharply increased. As Figure 4 illustrates, the share of unplumbed households in Portland, Oregon, jumped from 0.5% (27th place) in 2000 to 0.6% (second place) in 2017, a jaw-dropping increase. Similarly, Milwaukee, which is one of our case studies, leapt from 20th place to third place; Austin from 17th to fifth; Cleveland from 33rd to sixth; Nashville from 22nd to 12th; and Seattle from 37th to 14th.

Together, Figures 3 and 4 underscore two important points:

- While plumbing poverty in US cities is improving as a whole, our analysis reveals an uneven geography of household water access across the metros. More broadly, these trends suggest a lack of coherent federal policy and water infrastructure investment means that the United States lacks any 'safety net' for underperforming cities and their unplumbed residents.

- The 'worst offenders' in terms of plumbing poverty – those metros that jumped ranks between 2000 and 2017 – are some of the wealthiest and fastest-growing urban areas in the country, including San Francisco, Portland, Austin, Nashville, and Seattle. In short, environmental injustice also happens in the places we may least expect.

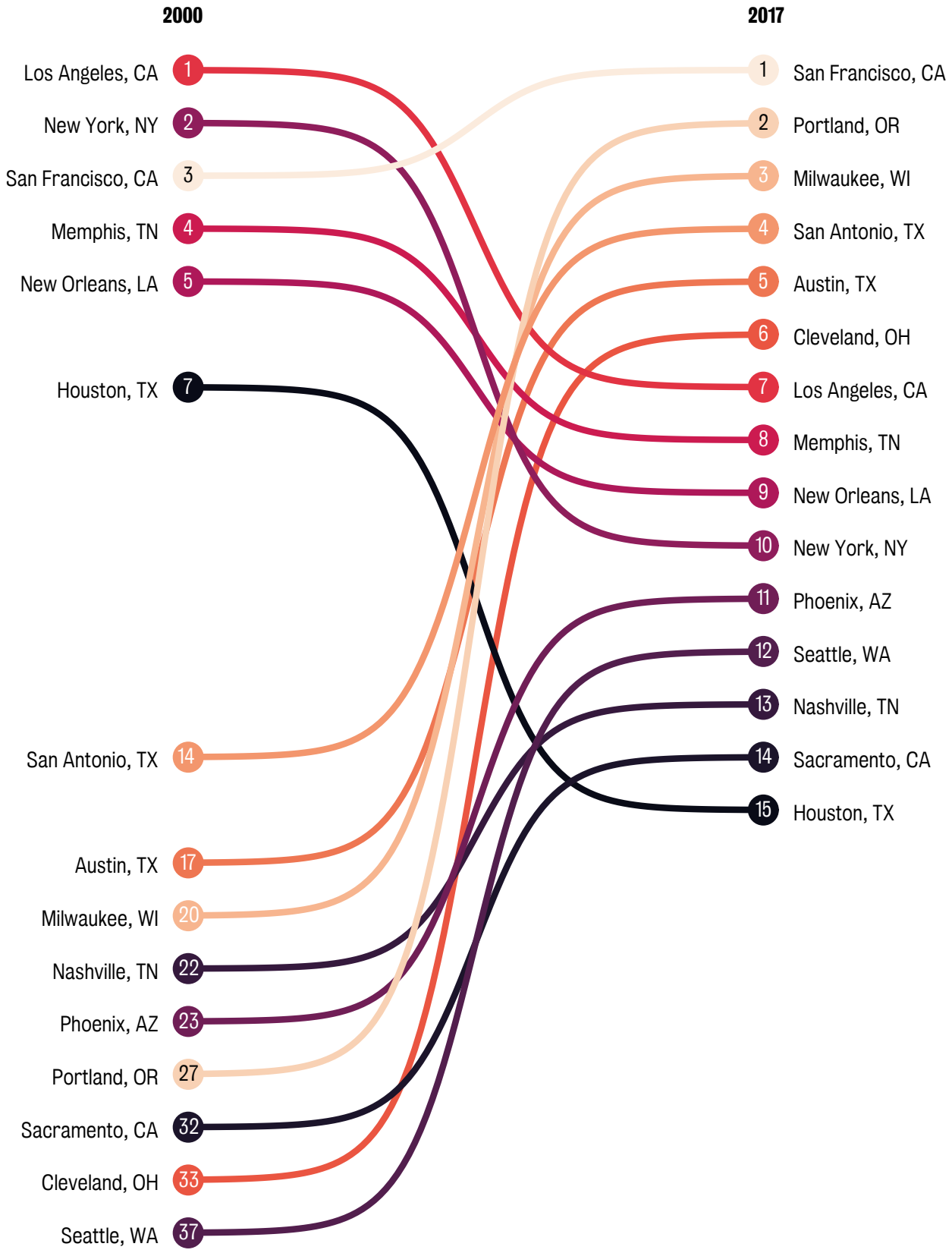
It is worth noting these data cannot explain the reasons for specific conditions and change in individual metros, which is an important area of future case study research. Nonetheless, our previous research and current results suggest that the persistence of urban plumbing poverty is rooted in racialized housing disparities and exacerbated by unaffordable housing conditions in some of the fastest-growing US cities.

Downtown Seattle Space Needle and Mount Rainier

PHOTO: STOCK.ADOBE.COM/MARKPAYNE

FIGURE 4: **Comparing cities: changes in plumbing poverty rank, 2000 to 2017**

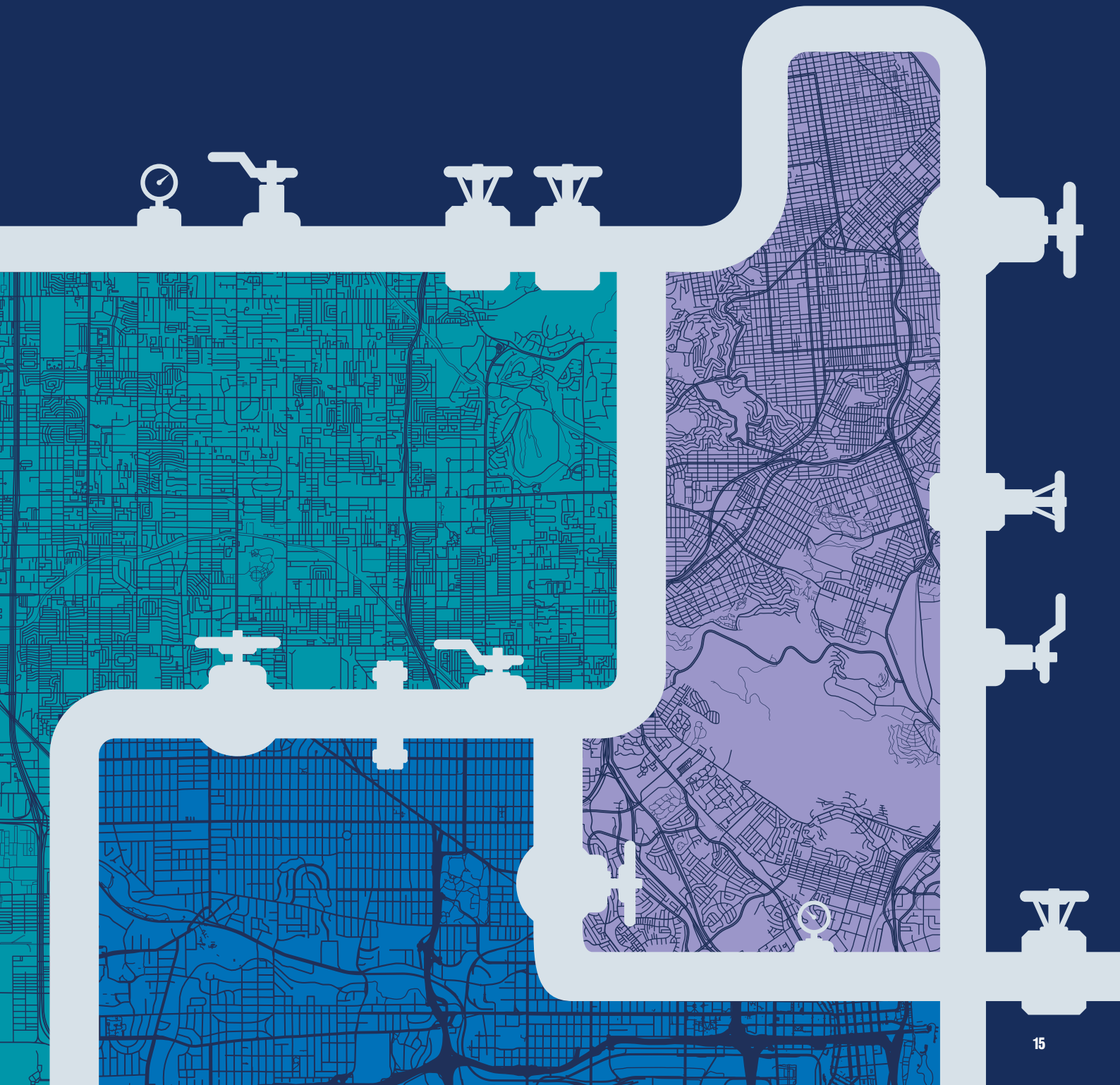
This diagram depicts the 15 'worst offender' metros in 2017 (listed at right, in descending order), by share (%) of population without piped water, with their corresponding rank in 2000 (at left), prior to the Great Recession of 2008. San Francisco graduated to the worst offender of the group by 2017. Los Angeles, the leader in 2000, 'improved' to seventh on the list.



Source: Visualized by authors using data from the US Census Bureau

Three city profiles

What are the different pathways of plumbing poverty in US cities? To provide a ground-level view of changes since 2000, we profile three indicative metros: San Francisco, Phoenix, and Milwaukee. Together, these metros exemplify key trajectories: (a) San Francisco is a strong example of 'worsening' trends in a dense and relatively wealthy city; (b) Phoenix captures the 'stagnation' of plumbing poverty in a fast-growing Sun Belt city; and (c) Milwaukee, too, reflects the 'stagnation' of plumbing poverty but in a deindustrialized Rust Belt context.

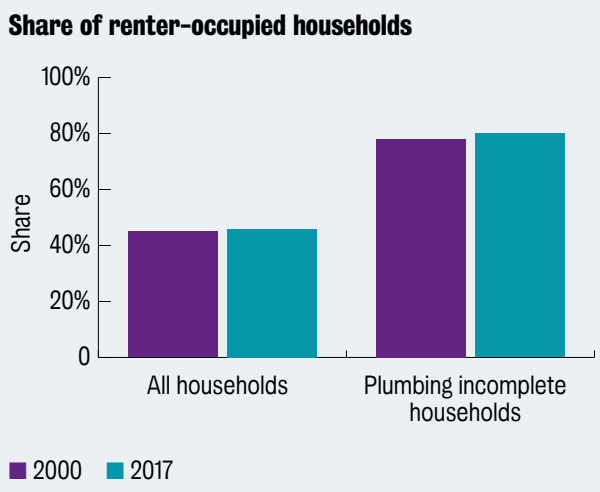


San Francisco: Plumbing poverty is a form of anti-Black urbanism

PHOTO: ISTOCKPHOTO.COM/DIANEBENTLEYRAYMOND

Aerial Birds Eye View of San Francisco Financial District

FIGURE 5: **A significant and disproportionately high share of unplumbed households in San Francisco are renters**[26]



Source: Calculated by authors using data from the US Census Bureau

Home to the third-most billionaires of all global cities and one of the largest unhoused populations in the United States, San Francisco epitomizes growing social inequality. San Francisco's growth and tech industry boom has been accompanied by declining homeownership, racialized displacement, securitization of the rental market, the emergence of 'corporate landlords', and increasingly untenable housing costs for low- and middle-income renters – trends that are tied to increasing rates of plumbing poverty.[27]

In 2017, San Francisco had the ninth-highest share of renter households in the United States. These renters earned the second-highest incomes and paid the second-highest housing costs in the country. Meanwhile, while San Francisco remains racially and ethnically diverse, it is one of the few major US metros where the Black population has declined since 2000. Both renters and Black households are among the San Franciscans worst affected by plumbing poverty.

From 2000 to 2017, the number of households with incomplete plumbing increased by 12%, or roughly 1,600 households, to 14,800 (Table 1). Among renter households, however, the increase in plumbing poverty over the same period was far worse: a total of 2,400 households or 23%. Indeed, renters consist of the bulk of unplumbed households in San Francisco. Renters make up less than half of households in the San Francisco metro area but account for nearly 90% of its plumbing poverty (Figure 5). Renters with incomplete plumbing, in other words, are a growing subclass in one of the richest and so-called 'progressive' US cities.

Compounding the problem, unplumbed renters in San Francisco are earning less and paying more for substandard services. San Francisco renters without piped water experienced a steep 29% drop in monthly income between 2000 and 2017, from $2,100 a month to $1,500 (Figure 6). This drop occurred even as the median household income for all San Francisco renters grew marginally, from $62,000 to $63,000. Median rent for unplumbed households remained relatively stable at $670 a month compared to monthly rents in the city overall, which rose from $1,300 to $1,700 (a 31% increase) over the period.

Shockingly, this analysis reveals that the average unplumbed renter in San Francisco in 2017 spent 44% of their monthly income to live in a home without piped running water, while the typical city resident spent a significant but far less burdensome chunk of their monthly household earnings – 32% – on a home with full plumbing.

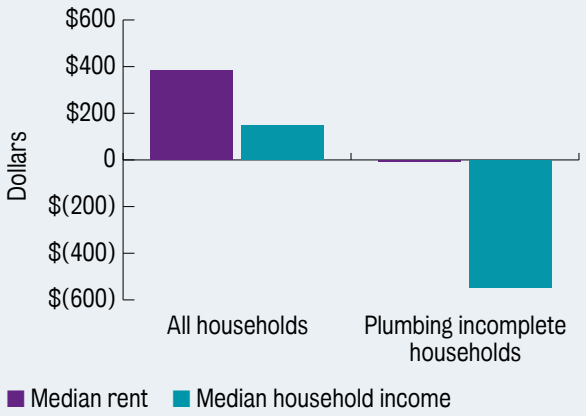
The growing rent burden for San Francisco households has coincided with large shifts in the metro's demographic composition. San Francisco is one of the most racially and ethnically diverse regions in the country, with 2.8 million people of color in 2017 compared to 2.1 million in 2000. At the same time, the city is one of the few top-50 metros where the Black population declined during the past two decades, from 418,000 in 2000 to 393,000 in 2017.

Despite San Francisco's shrinking Black population, the number of Black people in plumbing poverty increased by nearly 50% over that period, from 3,200 to 4,600 individuals. As of 2017, Black people made up 9% of the metro population but 17% of its unplumbed population. The story of plumbing poverty in San Francisco is inextricably tied to unaffordable housing, declining incomes, post-recession transformations in the California rental sector, and racialized wealth gaps, reflecting a kind of 'anti-Black urbanism' that has driven Black San Franciscans into more precarious housing conditions or out of the metro entirely.

"Shockingly, this analysis reveals that the average unplumbed renter in San Francisco in 2017 spent 44% of their monthly income to live in a home without piped running water"

FIGURE 6: **Renters in San Francisco pay a higher share of income for homes with no plumbing[28]**

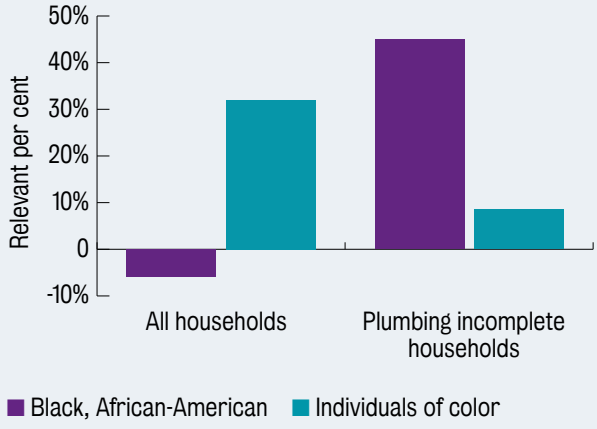
Change in median rent and median household income, 2000–2017



Source: Calculated by authors using data from the US Census Bureau

FIGURE 7: **San Francisco's Black population shrinks while the number of Black San Franciscans in plumbing poverty increases[29]**

Change in population by race/ethnicity, 2000–2017



Source: Calculated by authors using data from the US Census Bureau

Phoenix: No change in plumbing poverty = no real progress

PHOTO: ISTOCKPHOTO.COM/DAVEL5957

Phoenix skyline and cactuses

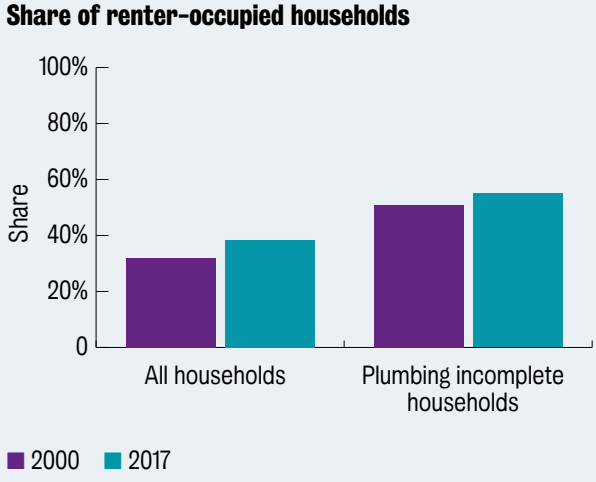
The capital of Arizona, Phoenix plays a vital role in the social and economic engine of the US Southwest. In 2017, Phoenix became the nation's 10th-largest metro region, having gained nearly 800,000 residents between 2000 and 2018. According to some metrics, Phoenix is a 'Best Performing City' in terms of job growth, wages, tech sector concentration, and low cost-burden for housing.[30] Despite its rapid growth and ambitious reputation, Phoenix is also a city of plumbing haves and have-nots, divided by hardening lines of class and property ownership.

From 2000 to 2017, the number of unplumbed households in Phoenix remained relatively unchanged, at roughly 6,000, while declining as a share of the metro population (Table 1). No change, however, equals no progress when it comes to the goal of universal water provision.

Phoenix renters are at a clear disadvantage when it comes to piped water access. Across the metro, renters comprised 39% of households (639,000) in 2017 but made up 55% of households (3,400) with incomplete plumbing. In 2000, by comparison, renters accounted for 32% of households in Phoenix and 51% of plumbing incomplete households, meaning the rate of unplumbed renters has grown alongside the overall share of rented households in the metro (Figure 8).

Phoenix renters have been hit both by rising rents and declining earnings. From 2000 to 2017, median monthly rent across the metro increased by $130 (14%) to $1,030 while median household income for Phoenix renters fell by $170 (5%) to $3,370. These trends were exaggerated among renters in plumbing poverty, whose rents rose by $250 (38%) while their median incomes fell by $230 (10%) to $2,070. In 2017, unplumbed renters in Phoenix spent 43% share of their monthly income on rent, compared to 31% for all renters in the metro. This trend marks a dramatic change from 2000, when the share of median income that all renters and plumbing poor renters spent on their monthly rent was relatively comparable, at 25% and 28%, respectively. Once again, unplumbed households expend a disproportionate share of resources to live in homes without hot and cold running water. Put differently, compared to almost two decades ago, Phoenix renters are earning less and paying more to live in a home without running water.

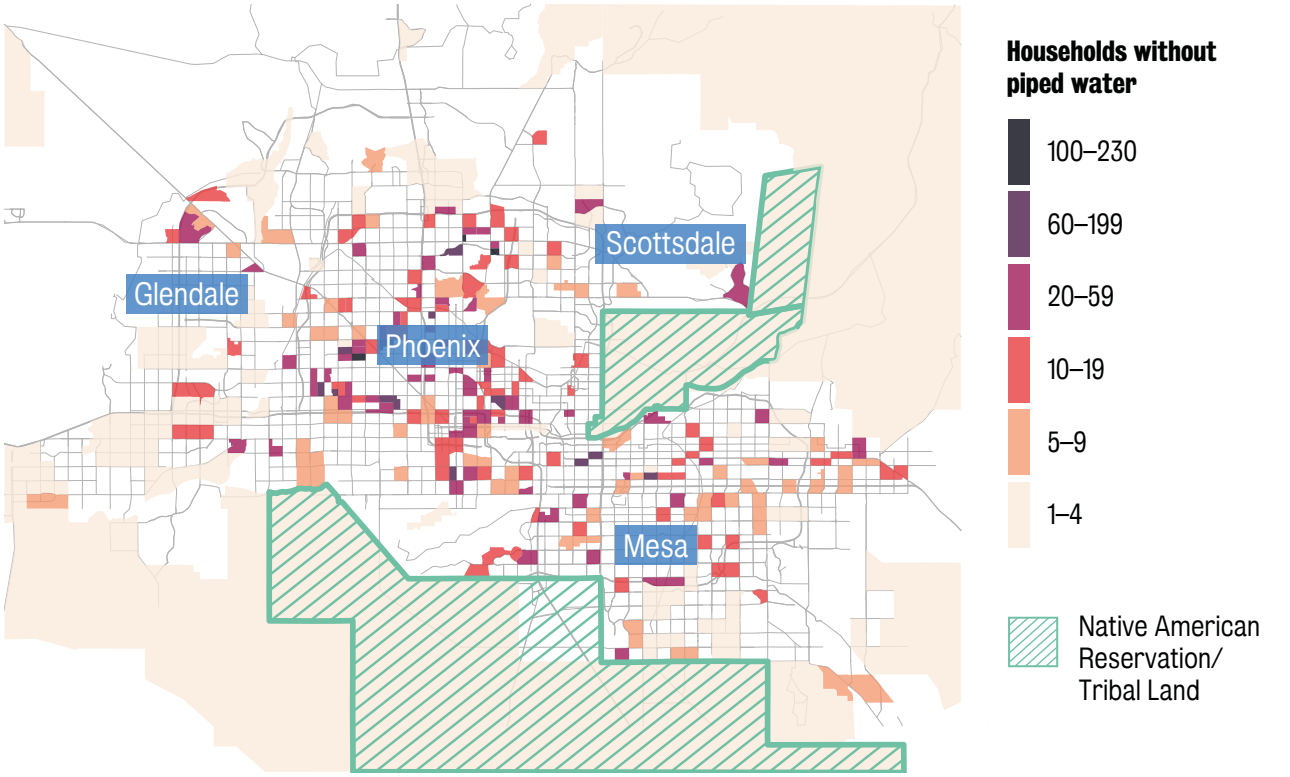
FIGURE 8: **Renter-occupied households, Phoenix, 2000 to 2017**



Source: Calculated by authors using data from the US Census Bureau

FIGURE 9: **Households without piped water in metro Phoenix, 2017.**

This map illustrates the number of unplumbed households per square mile by census tract, a visualization method to prevent the over-representation of large tracts within the metro.



Source: Cartography by the authors using data from the US Census Bureau.

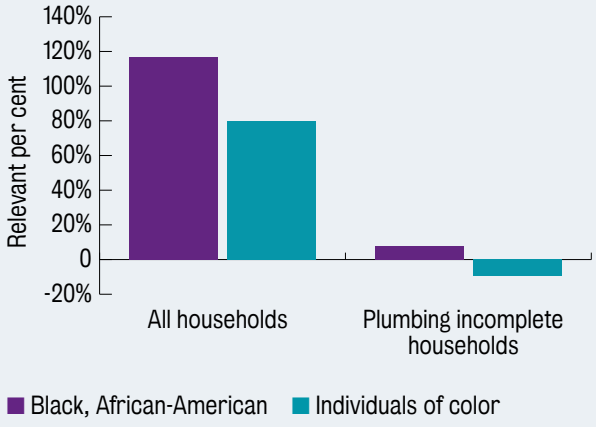
Where are households without piped water in metro Phoenix? As Figure 9 shows, unplumbed households are scattered throughout the metro region, not limited to one neighborhood or geographic area. However, our results do point to higher concentrations in and around the downtown Phoenix core, north Phoenix/ Deer Valley, Peoria, outer Sun City West, Guadalupe, and neighborhoods across Mesa and Gilbert.

Compared to San Francisco and Milwaukee, the racial disparities among Phoenix's unplumbed population are less pronounced, an interesting finding (Figure 10). Like many US cities, Phoenix has become more racially diverse over the past two decades. For example, Phoenix boasted remarkable growth in the Black/African American population (126,000 to 274,000 individuals between 2000 and 2017, an increase of 117.1%), as well as among people of color more generally (1,129,000 to 2,031,000 individuals, an increase of 80.0%).

However, the number of Phoenicians without piped water who are Black/African American or individuals of color remained unchanged between the two periods. This trend in Phoenix is in sharp contrast to San Francisco, where communities of color face more systemic obstacles to housing stability, such as finding an affordable rental with running water and toilet facilities. The story of Phoenix reveals not so much an acceleration of plumbing poverty as in San Francisco, but rather a hardening of existing class divides and housing opportunities among the plumbed and unplumbed.

FIGURE 10: **Relative population change by race/ ethnicity in metro Phoenix, 2000 to 2017**[31]

Change in population by race/ethnicity, 2000–2017



Source: Calculated by authors using data from the US Census Bureau

Milwaukee: A legacy of infrastructural redlining

PHOTO: ISTOCKPHOTO.COM/SEAN PAVONE

Milwaukee, Wisconsin, downtown city skyline on Lake Michigan

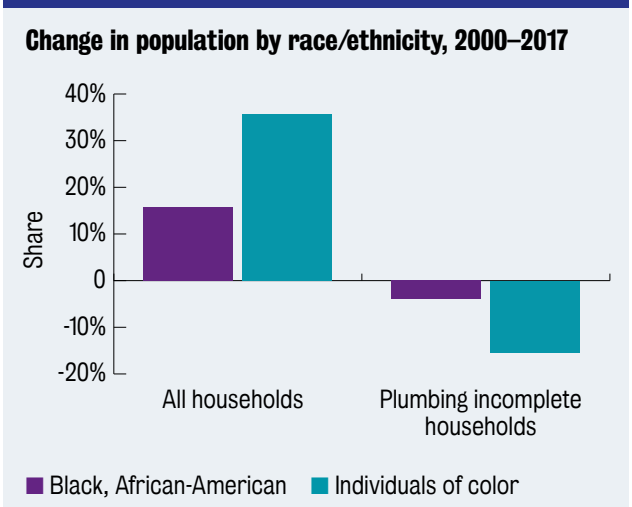
The largest city in Wisconsin, Milwaukee is one of the nation's leading industrial cities. Industrial manufacturing, metalworking, machining, railroads, and breweries made Milwaukee famous. The region, originally occupied by Indigenous peoples, drew German and Polish immigrants in the 1800s followed by African American migrants from the American South in the 1900s as part of the Great Migration. Robust economic opportunity, well-paying union jobs, and the prospect of upward social mobility made Milwaukee a destination.

More recently, deindustrialization and the decline of union employment have contributed to increasing economic uncertainty for many Milwaukeeans. This economic hardship has in turn made it difficult for many Rust Belt cities to attract and retain residents. Over the past 20 years, the Milwaukee metro region added fewer than 100,000 residents while the city lost population. An eroding tax base and increased demand for social services has placed pressure on the existing physical and social infrastructure.

In terms of water infrastructure, plumbing poverty in Milwaukee remains unchanged, at around 3,000 unplumbed households between 2000 and 2017. In terms of ranking, Milwaukee jumped from 20th place to third place among metro areas with the highest relative share of household plumbing poverty between 2000 and 2017 (Figure 4).

Milwaukee is one of the most racially segregated cities in the country, shaped by redlining practices that systematically disadvantaged communities of color (for example, by grading neighborhoods based

FIGURE 11: **Relative population change by race/ethnicity, Milwaukee, 2000 to 2017**[32]



Source: Calculated by authors using data from the US Census Bureau

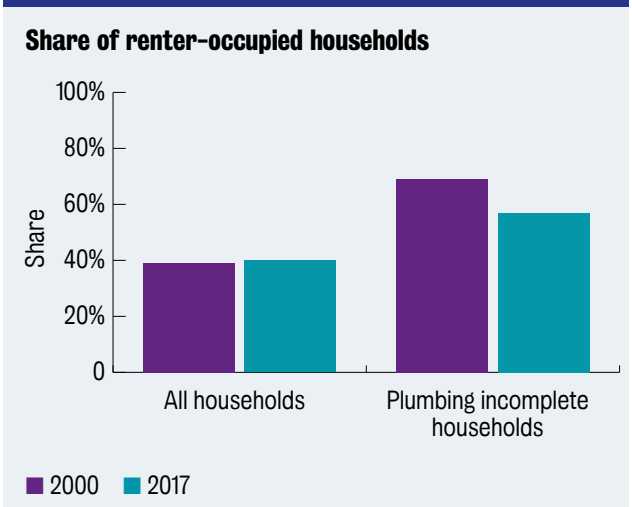
on mortgage lending risk and racial identity) and shaped its urban geography.[33] Legacies of redlining, institutional discrimination, and anti-Black urbanism have created an unequal and unjust environment for people of color, especially Black Milwaukeeans. According to some experts, 'Black Milwaukee is generally worse off today than it was 40 or 50 years ago.'[34]

In 2017, 28% of individuals with incomplete plumbing were Black/African American, even though Black individuals comprise just 16.1% of the metro population. At the same time, the metro recorded a robust increase in racial/ethnic diversity without accompanying increases in households with incomplete plumbing (Figure 11). Future research is needed to investigate the geography of overrepresentation among Black Milwaukeeans and whether the unequal outcomes of plumbing poverty represent a new form of infrastructural redlining in the city.

A key finding is that the renter-owner divide is less severe in Milwaukee than in other metro areas (Figure 12). Two pieces of evidence underscore this point. First, as of 2017, Milwaukee renters made up roughly 40% of all households and 60% of plumbing incomplete households, which is closer to parity (i.e., 50%-50%) than in many other metros. Second, the share of plumbing incomplete rental households declined to 57% in 2017 from 69% in 2000, implying an increase in homeownership among households without complete plumbing during that same period. This is notable as our analysis has not revealed an increase in homeownership among unplumbed households from 2000 to 2017 in any other city.

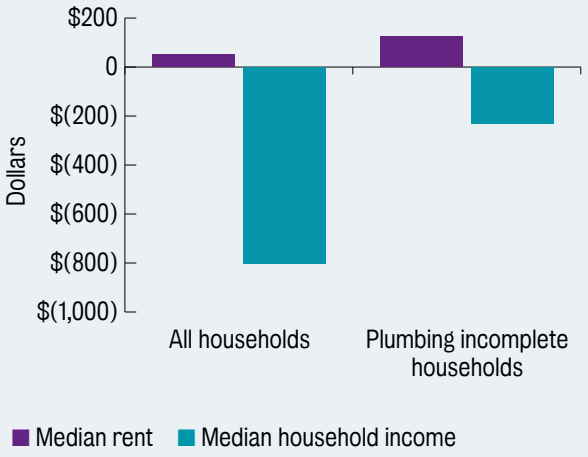
Compared to Phoenix and San Francisco, the Milwaukee housing market is more affordable. We examined the median home sales list price for April 2008 (prior to the Great Recession) and April 2017 from Zillow, an online real estate marketplace. In San Francisco, the median home list price rose from $664,000 in 2008 to $729,000 in 2017, a 9.8% increase.[35] In Phoenix and Milwaukee, however, the median home list price fell during this period, accounting for inflation. The median list price declined by $16,000 (-5.5%) in Phoenix ($263,000 in 2008 and $247,000 in 2017) and by $20,000 (-9.4%) in Milwaukee ($213,000 in 2008 and $191,000 in 2017). These data, a rough proxy for housing cost, point to greater relative affordability of the Milwaukee housing market compared to other metro areas.

FIGURE 12: **Renter-occupied households, Milwaukee, 2000 to 2017**



Source: Calculated by authors using data from the US Census Bureau

FIGURE 13: **Median rent and median household income for renter-occupied and plumbing incomplete households, Milwaukee, 2000 to 2017**



Source: Calculated by authors using data from the US Census Bureau

While homeownership may be more accessible in Milwaukee, conditions are becoming more precarious for the city's renters. Between 2000 and 2017, median household income declined by $800 (23%) (Figure 13). This severe decline – the largest decrease in median household income across the three city case studies – is likely a product of wage stagnation, decreasing union employment, and economic hangover effects from deindustrialization.[36] Median rent for renters increased by $50 (or 6.6%) over the same period. For unplumbed renter households in Milwaukee, median rent increased by $130 (19%) from 2000 to 2017 while median household income remained statistically unchanged, a combination that underscores the rising housing precarity for households with incomplete plumbing. In 2017, unplumbed households spent roughly half (49%) of their monthly income on rent, compared to a 31% share for all renters in the Milwaukee metro. The rent burden gap in Milwaukee is the highest across the three profiled metros.

Policy recommendations

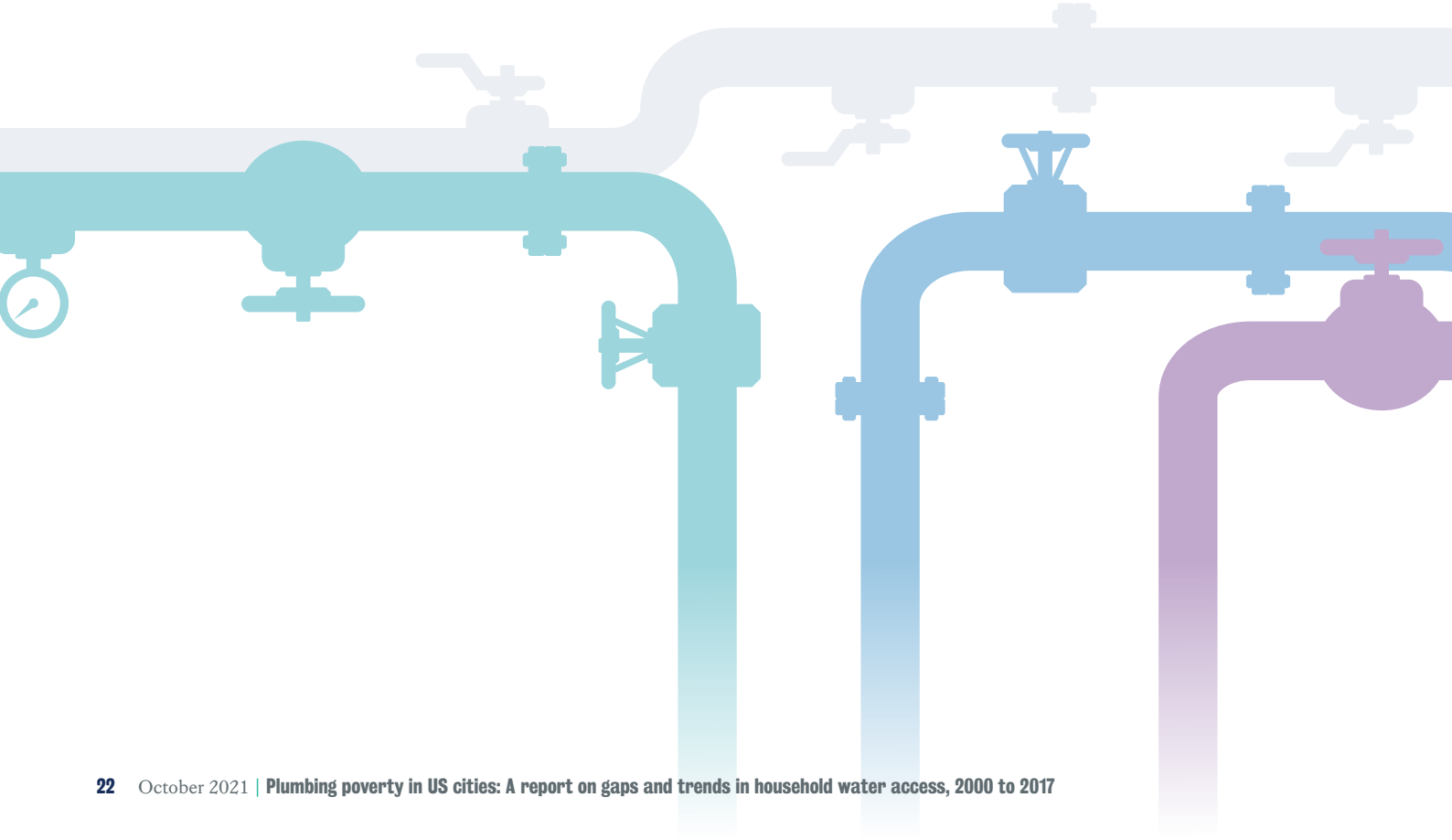
What next? Coherent federal policies and significant investment are sorely needed to improve conditions of infrastructural equality and piped water access. Based on our research, we set out several priorities for tackling household water insecurity in US cities.

Fix the plumbing question

Bring back the toilet question.
In 2016, the US Census Bureau removed the flush toilet question from its survey and re-defined 'complete plumbing' as only running water and a shower or bath (Box 1). Despite this removal, an estimated 106,000 people lacked a flush toilet in their home as of 2015. Rather than wipe this population from the record, we should reintroduce the toilet question in order to better track sanitation access. Without the toilet question, we have no comprehensive, sanitation-sensitive data resources to monitor US progress toward UN Sustainable Development Goal 6: Clean Water and Sanitation for All.

Expand the plumbing question.
Ahead of the next ACS, the plumbing question should be improved and *expanded* to paint a fuller picture of household water security. For example, follow-up questions should be added to gather information about water service provider (public or private?), water status (shut off or running?), and affordability. Presently, the United States has no comprehensive database to account for household water shut-offs and affordability, which are key elements of secure water access.[37] In the latest ACS, the Census asked three detailed, multi-part questions about internet access. Why should something as fundamental to human health and livelihood as water be given any less thorough treatment?

> An estimated 106,000 people lacked a flush toilet in their home as of 2015. Rather than wipe this population from the record, we should reintroduce the toilet question.



A green New Deal for infrastructural justice

Connect unplumbed households to the grid.

Introduced in 2021, the bipartisan Infrastructure and Investment Jobs Act is a landmark $550 billion federal investment in US infrastructure. Among its provisions is the 'largest investment in clean drinking water in American history': $55 billion to replace lead pipes and service lines and remove dangerous PFAS chemicals from piped water. We recommend some of this $55 billion also be used to connect unplumbed homes to the grid, similar to how the Public Works Administration funded most water infrastructure projects in small, rural communities during the New Deal.[38] One option would be to create a national fund that works with urban water districts to subsidize network extension and lift households out of plumbing poverty. While we applaud efforts to repair and clean up existing water connections, we must not forget the 1.1 million Americans who lack any mechanism to access clean water in the first place.

Construct coherent federal policies to regulate water affordability and shut-offs.

Part of secure water access is having a reliable and affordable source of running water. As the Detroit case illustrates, water shut-offs are endemic in cities across the United States, and they are potentially lethal in a global health crisis and pandemic. We advocate for nationwide policies and regulations to make water affordable and limit shut-offs as a punitive measure. What good is piped access without any running water?

Create a federal task force to monitor US household water insecurity.

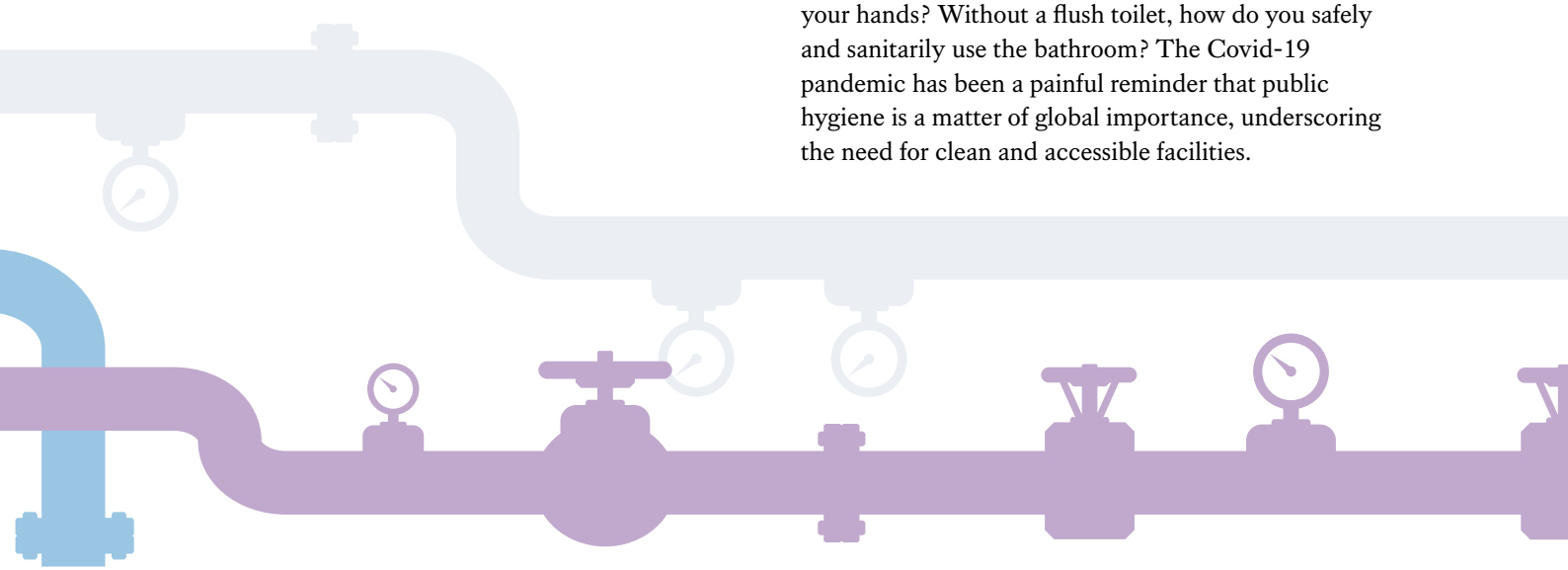
Our research suggests that water injustices like service gaps, shut-offs, and quality crises are produced and perpetuated at the local level: for instance, without federal oversight or regulations, standards for connecting customers or preventing water shut-offs vary widely across cities. We recommend creating a federal body that can monitor the national state of household water insecurity and coordinate solutions with state and local institutions.

Strengthen renter protections against exploitative housing conditions.

Urban US renters disproportionately experience plumbing poverty, especially renters living in affluent, unaffordable cities. This is despite the fact that many of the cities profiled in our report already ban landlords from renting substandard housing, like homes without piped water or a flush toilet. Clearly, we need better laws and regulations and more robust enforcement to protect renters from landlords who rent unplumbed properties to low-income tenants, often at exorbitant rates.

Fund and maintain free public water and sanitation facilities.

Across US cities, many public toilets and water sources like water fountains have closed, fallen into disrepair (for instance, toilets without doors or soap to deter use), or been functionally replaced with 'pay-to-use' services (bathrooms in private facilities like Starbucks, bottled water sold in convenience stores). Without access to running water, how do you wash your hands? Without a flush toilet, how do you safely and sanitarily use the bathroom? The Covid-19 pandemic has been a painful reminder that public hygiene is a matter of global importance, underscoring the need for clean and accessible facilities.



> Without access to running water, how do you wash your hands? Without a flush toilet, how do you safely use the bathroom? The Covid-19 pandemic has been a painful reminder that piped water and public hygiene are a matter of global importance, including in the United States.

Conclusion

This report aims to understand how plumbing poverty manifests across urban America, where we may least expect to find it. While piped water access has improved across US cities as a whole since 2000, our research reveals that plumbing poverty is stagnating or getting worse in some high-growth cities. This uneven geography of household water access is perpetuated by the lack of coherent federal policy and significant water infrastructure investment in the United States, such that unplumbed urban residents lack any sort of 'safety net' of water provision, much less a guarantee of safe and secure access to water and sanitation, a fundamental human right.

The 'worst offenders' in terms of plumbing poverty – metros that recorded the largest gains in share of unplumbed households from 2000 to 2017 – are some of the wealthiest and fastest-growing US cities, such as San Francisco, Portland, Austin, Nashville, and Seattle. Our analysis reveals a clear link between plumbing poverty and housing precarity. Households in plumbing poverty are disproportionately renters rather than homeowners; compared to other renters they also are more rent-burdened, spending between a 40% and 50% share of monthly household income on rent in our three case study cities, roughly 10 to 15 percentage points more than all renters in those same metros. This finding is particularly startling as this hefty rent burden is spent on housing without complete plumbing facilities and which would likely be considered substandard.

Our analysis also demonstrates the stark racial disparities of piped water access. In San Francisco, the number of Black people in plumbing poverty increased nearly 50% from 2000 to 2017 even as the Black population declined in the metro; in Phoenix, the number of Black residents in plumbing poverty stayed the same over that period, which we equate with no progress; and in both San Francisco and Milwaukee the share of Black households in plumbing poverty as of 2017 was roughly double the Black share of the metro population.

Through our analysis of 15 select US metros and focus on three case studies, this report charts the divergent paths of plumbing poverty in urban America. This work underscores a need for government action to rectify the injustices of domestic water infrastructure. As the Biden administration and US Congress prepare to 'build back better' and pump $55 billion into cleaning up piped water, it would do well to also direct some of that investment to connecting the 1.1 million unplumbed Americans to the grid, the vast majority of whom live in cities and in relatively close proximity to existing water infrastructure. The costs of doing so, while prohibitive for many individuals, should be considered minimal compared to the corresponding gains in health, safety, and quality of life that secure and reliable access to piped water confers.

Annex A: About the data and analysis

Our research used household-level data (known as microdata) to assess social and demographic trends in plumbing poverty and compare metropolitan performance between US metropolitan areas.[39] Household data were sourced from IPUMS (based at the University of Minnesota and available for download), taken from the years 2000 and 2013-2017.[40] IPUMS includes almost a billion records from the US Census Bureau, dating from 1790. IPUMS data have the advantage of using harmonized variable codes and documentation to remain consistent across datasets. In contrast to summary or aggregate data, microdata are composed of individual and household records, thus allowing us to avoid the problem of ecological fallacy present in aggregated studies.[41]

Who is included in a household? According to the US Census Bureau, any occupied housing unit, regardless of the number of people living there or their relation to one another, is considered a household.[42]

However, we note important data nuances with respect to people experiencing homelessness. For people in certain housing situations, such as 'doubled up' with other families or living in a Single Room Occupancy (SRO) residence, common forms of affordable housing in San Francisco and New York City, they are counted as households by the ACS and decennial census. Individuals not residing in housing units and instead living in institutional settings – such as homeless shelters, nursing homes, and correctional facilities – are counted as part of the 'group quarters' category. While the Census still collects demographic information about group quarters, the list of questions is slightly different and the plumbing question is not included.[43] Unfortunately, these categorical nuances limit the ability of researchers to understand piped water access for the full spectrum of people experiencing homelessness.

Building on results from previous nationwide studies,[44] this report sought to identify comparative trends and patterns of plumbing poverty between metros, and how patterns have changed since 2000. Ultimately, the goal of this analysis was to facilitate a stronger understanding of how plumbing poverty manifests unevenly through time and across different urban areas. The selected time frame of analysis – before and after the Great Recession of 2008, a pivotal moment in the US housing crisis – allows us to gauge trajectories and possible underlying factors at the nexus of housing and water, particularly in cities where plumbing poverty is plateauing or getting worse.

Our analysis proceeded in three parts. First, we calculated the total number and share of unplumbed households in 2000 and 2017, accounting for the change in the US Census Bureau's definition of complete plumbing (see Box 2). Second, we calculated descriptive statistics for all households and persons, and all unplumbed households and persons. Finally, we tested for real differences between unplumbed populations and entire metro populations for 2000 and 2017. All changes and differences we report are statistically significant at the 90% confidence level unless otherwise noted.

We produced all figures, tables, and estimates using R (an open-source statistical software program) and Microsoft Excel.[45] All R code and metropolitan definitions developed by the authors are available for download and use in a citable format.[46]

San Francisco-Oakland-Hayward, CA	Total Households		Plumbing Incomplete Households		PP Difference, 2000 to 2013-2017	
	2000	2017	2000	2017	Estimate	Significance
Number of Households	1,550,694	1,684,077	13,155	14,787	1,632	*
Renter-Occupied Households	691,059	777,983	10,220	12,620	2,400	*
Median Rent	$1,298	$1,682	$679	$673	-$7	
Monthly Median Household Income (MHI)	$5,131	$5,279	$2,077	$1,532	-$545	*
Black, African-American Individuals	418,491	393,033	3,178	4,596	1,418	*
Individuals of Color	2,104,338	2,768,109	22,361	20,455	-1,906	

Phoenix-Mesa-Scottsdale, AZ	Total Households		Plumbing Incomplete Households		PP Difference, 2000 to 2013-2017	
	2000	2017	2000	2017	Estimate	Significance
Number of Households	1,214,664	1,658,972	5,810	6,219	409	
Renter-Occupied Households	386,318	638,618	2,972	3,420	448	
Median Rent	$901	$1,028	$648	$895	$247	*
Monthly Median Household Income (MHI)	$3,543	$3,369	$2,297	$2,068	-$229	
Black, African-American Individuals	126,010	273,587	952	1,037	85	
Individuals of Color	1,128,575	2,031,237	12,102	10,979	-1,123	

Milwaukee-Waukesha-West Allis, WI	Total Households		Plumbing Incomplete Households		PP Difference, 2000 to 2013-2017	
	2000	2017	2000	2017	Estimate	Significance
Number of Households	587,676	627,824	2,958	3,341	383	
Renter-Occupied Households	228,914	251,773	2,052	1,921	-131	
Median Rent	$807	$860	$657	$782	$126	*
Monthly Median Household Income (MHI)	$3,543	$2,740	$1,833	$1,602	-$231	
Black, African-American Individuals	237,800	275,450	2,570	2,467	-103	
Individuals of Color	381,094	516,984	4,214	3,563	-651	

Source: Calculated by authors using data from the US Census

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4 See Pauli (2019, 2020). The Flint water crisis has been extensively covered by national news media and filmmakers. See, for example, "Thirst for Justice" (2019) a documentary film on contaminated water struggles in Flint, Michigan and the Navajo Nation, directed by Leana Hosea.

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10 Around the world, women are disproportionately tasked with the labor, management, responsibility, and care work of domestic water provision. There is a substantial academic literature on this topic. For a brief overview, see: Caruso, B.A., V. Sevilimedu, I. C-H Fung, and K.K. Baker. (2015) Gender disparities in water, sanitation, and global health. *The Lancet* 386(9994): 650-651 DOI: 10.1016/S0140-6736(15)61497-0.

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23 Raglin, D.A. (2015, May 29) *American Community Survey Research and Evaluation Report Memorandum Series* #ACS15-RER-06. Retrieved from https://www.census.gov/content/dam/Census/library/working-papers/2015/acs/2015_Raglin_01.pdf

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26 The change in plumbing incomplete households headed by a Black/African American and individual of color between 2000 and 2017, at -4.0% and -15.4%, respectively, is non-statistically significant.

27 Barton, S.E. (2011) Land rent and housing policy: A case study of the San Francisco Bay Area rental housing market. *American Journal of Economics and Sociology* 70(4): 845-873 DOI: 10.1111/j.1536-7150.2011.00796.x; Fields, D. (2018) Constructing a new asset class: Property-led financial accumulation after the crisis. Economic Geography 94(2): 118-140 DOI: 10.1080/00130095.2017.1397492; Fields, D., R. Kohli, and A. Schafran. (2016) The Emerging Economic Geography of Single-Family Rental Securitization. San Francisco, CA: Federal Reserve Bank of San Francisco, Community Development Investment Center, Working paper 2016-02. Retrieved from http://www.frbsf.org/community-development

28 For households without piped water in San Francisco, their rent remained stable from 2000 to 2017 but their income dropped precipitously, meaning they pay more for rent as compared to renter households with piped water. The change in median rent for unplumbed renter households between 2000 and 2017 was virtually the same (-$7) and is non-statistically significant.

29 The change in plumbing incomplete households headed by an individual of color between 2000 and 2017 (8.5%) is non-statistically significant, largely because individuals of color already make up 75% of individuals without complete plumbing in San Francisco.

30 https://www.azeconomy.org/2021/03/economy/phoenix-now-a-tier-1-city

31 The change in plumbing incomplete households headed by a Black/African American and individual of color between 2000 and 2017, at 8.9% and -9.3%, respectively, is non-statistically significant.

32 The change in plumbing incomplete households headed by a Black/African American and individual of color between 2000 and 2017, at -4.0% and -15.4%, respectively, is non-statistically significant.

33 https://s4.ad.brown.edu/projects/diversity/Data/Report/report2.pdf

34 https://uwm.edu/ced/new-the-state-of-black-milwaukee-in-national-perspective-racial-inequality-in-the-nations-50-largest-metropolitan-areas-in-65-charts-and-tables

35 These estimates account for inflation.

36 Decline in median household income across the three metros is in absolute and relative terms. In short, households are earning less now than they did two decades ago.

37 One of the best recent nationwide studies of household water affordability and shut-offs was conducted by Food & Water Watch. Because of national data limitations, they had to rely on self-reported data from utilities. Not surprisingly, privately-owned water utilities had the lowest response rate, leading to an incomplete national portrait. See: Food & Water Watch (2018) *America's Secret Water Crisis: National Shutoff Survey Reveals Water Affordability Emergency Affecting Millions.* Washington, DC: Food & Water Watch National Office. Retrieved from https://www.foodandwaterwatch.org/wp-content/uploads/2021/03/rpt_1810_watershutoffs-web2.pdf

38 Melosi (2011, p. 64).

39 Deitz and Meehan (2019).

40 Manson, S., Schroeder, J., Van Riper, D., Kugler, T., and S. Ruggles. IPUMS National Historical Geographic Information System: Version 16.0 [dataset]. Minneapolis, MN: IPUMS. 2021. http://doi.org/10.18128/D050.V16.0

41 See methodological discussion in Deitz and Meehan (2019).

42 https://www.census.gov/glossary/#term_Household

43 https://www2.census.gov/programs-surveys/acs/methodology/questionnaires/2017/quest17GQ.pdf

44 Deitz and Meehan (2019), Meehan et al. (2020).

45 We used the following CRAN packages to analyze and visualize the data: tidyverse, tidycensus, survey, and ggplot2. All tables and column charts were produced in Microsoft Excel.

46 Meehan, Katie; Jason R. Jurjevich; Nicholas M.J.W. Chun, and Justin Sherrill. (2020). Metropolitan Geographic Definitions and Code for "Geographies of Insecure Water Access and the Housing-Water Nexus in US Cities." Tucson, AZ: University of Arizona Research Data Repository. https://doi.org/10.25422/azu.data.12456536

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