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Review article

The (in)visible health risks of climate change

Luke Parry^{a,b,*}, Claudia Radel^c, Susana B. Adamo^d, Nigel Clark^a, Miriam Counterman^e,
Nadia Flores-Yeffal^f, Diego Pons^g, Paty Romero-Lankao^h, Jason Vargoⁱ^a Lancaster Environment Centre, Lancaster University, UK^b Nucleus of Advanced Amazonian Studies (NAEA), Federal University of Pará, Brazil^c Department of Environment and Society, Utah State University, UT, USA^d CIESIN, Columbia University, Palisades, NY, USA^e Department of Sociology, University of Colorado Boulder, CO, USA^f Department of Sociology, Anthropology & Social Work, Texas Tech University, TX, USA^g Department of Geography and the Environment, University of Denver, CO, USA^h National Center for Atmospheric Research (NCAR), Boulder, CO, USAⁱ Global Health Institute and the Nelson Institute for Environmental Studies, University of Wisconsin-Madison, WI, USA

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ABSTRACT

This paper scrutinizes the assertion that knowledge gaps concerning health risks from climate change are unjust, and must be addressed, because they hinder evidence-led interventions to protect vulnerable populations. First, we construct a taxonomy of six inter-related forms of invisibility (social marginalization, forced invisibility by migrants, spatial marginalization, neglected diseases, mental health, uneven climatic monitoring and forecasting) which underlie systematic biases in current understanding of these risks in Latin America, and advocate an approach to climate-health research that draws on intersectionality theory to address these inter-relations. We propose that these invisibilities should be understood as outcomes of structural imbalances in power and resources rather than as haphazard blindspots in scientific and state knowledge. Our thesis, drawing on theories of governmentality, is that context-dependent tensions condition whether or not benefits of making vulnerable populations legible to the state outweigh costs. To be seen is to be politically counted and eligible for rights, yet evidence demonstrates the perils of visibility to disempowered people. For example, flood-relief efforts in remote Amazonia expose marginalized urban river-dwellers to the traumatic prospect of forced relocation and social and economic upheaval. Finally, drawing on research on citizenship in post-colonial settings, we conceptualize climate change as an ‘open moment’ of political rupture, and propose strategies of social accountability, empowerment and trans-disciplinary research which encourage the marginalized to reach out for greater power. These achievements could reduce drawbacks of state legibility and facilitate socially-just governmental action on climate change adaptation that promotes health for all.

1. Introduction

Climatic variability and change poses major threats to global health through risks to people's physical and mental health and well-being (Berry et al., 2018). The World Health Organization (2014) predicts five million additional deaths between 2030 and 2050 from climate change, which is a significant under-estimate because it does not account for increased climate change exposure from urbanization, population growth, aging, and migration (Watts et al., 2015). Health risks from climate change are amplified by social inequalities (Smith et al., 2014) and climate-impacts exacerbate vulnerability. Health researchers consider that to adequately manage population health under a changing

climate, the challenge is how to “develop and implement adaptive health systems that incorporate surveillance, emergency-response, and long-term planning functions and facilitate institutional change and interaction” (Mayhew and Hanefeld, 2014). Berry et al. (2018) endorse the necessity of ‘factual’ knowledge, arguing: “It is increasingly necessary to quantify the impacts of climate change on populations, and to quantify the effectiveness of mitigation and adaptation strategies”. Reducing climate-health impacts through evidence-led interventions is a moral imperative because risks are greater for poorer and marginalized populations within and across regions (Friel et al., 2008). Those who have contributed least to greenhouse gas emissions are likely to be hurt ‘first and worst’. This paper's point of departure is that climate-health linkages pose major,

* Corresponding author. Lancaster Environment Centre, Lancaster University, Lancaster, LA1 4YQ, UK.

E-mail address: luke.parry@lancaster.ac (L. Parry).<https://doi.org/10.1016/j.socscimed.2019.112448>

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unjust risks to vulnerable populations yet knowledge gaps and uncertainties limit current understanding (Watts et al., 2015). We use *invisibility* to identify and scrutinize systematic biases in current understanding of climate health-risks (herein, CHR), which are unevenly distributed across spatial and socio-economic gradients.

1.1. (In)visibility and governmentality

Climate-health ‘invisibilities’, something not recognized or seen as important (Turner et al., 2008), pose a wicked problem because on the one hand, they constrain societal actions to prevent harm through risk management: disease prevention, control and adaptation. On the other, they can reflect strategies of hiding by marginalized people under pressure who disproportionately experience costs of state legibility. Making visible a spatially bounded population and its demographic and health characteristics is the technique of power of the modern state, which ultimately justifies societal investment in scientific research. We draw upon connections made by Michel Foucault between the mission of the modern state to foster life and the task of rendering its populace visible, and James Scott’s notion that modern statecraft relies upon data-gathering, management and analysis to ground effective intervention.

Foucault introduced the concept of ‘governmentality’ to describe growing state concern with people’s everyday lives. The state’s task, he argued (2007, p.105), becomes “*not just to govern, but to improve the condition of the population, to increase its wealth, its longevity, its health*”. Key to this intensified intervention in the life chances and conduct of ordinary people is state’s capacity to ‘see’ those under its jurisdiction. Working in tandem with a new prominence of technical experts is the growing importance of statistics - ‘the science of the state’ (Foucault, 1994, p.212), which aims to identify properties and dynamics of the population as a whole.

Scott (1998) is similarly concerned with the centrality of visualizing technologies to modern statecraft, stressing how state-led representational practices reduce complex realities to simplified facts. More starkly than Foucault, Scott links advancing state visualization to ambitions for comprehensive social and physical engineering (1998, pp.3–4). Whereas Scott emphasizes the state’s use of data-gathering to impose new forms of order as if the people were a blank slate, Foucault gives more attention to how states seek to work with the properties and powers of the people that their gaze has revealed. Governmentality entails state intent to shape subjects’ behaviour, but Foucault foregrounds the ways in which modern states encourage individuals and communities to become active partners in managing and monitoring their own wellbeing. In this way, power is ideally dispersed throughout society (1994, p.334).

We should not underestimate the benefits that proceeded intensified modern governance of daily life, including disease prevention and reduced mortality. Even Scott, with his deep distrust of state information-gathering concedes that it can “*permit discriminating interventions, some of which are literally lifesaving*” (1998, p.77). But both Scott and Foucault insist that modern state visualization strategies and the interventions they inform do not go unopposed. Foucault notes how advancing state influence over daily life, no matter how tactical, provokes popular resistance or ‘counter-conduct’ (2007, p.355). More emphatically, Scott identifies ways through which people targeted by lofty state-led schemes seek to evade visualization and control.

Giorgio Agamben’s (1998) discussion of the ‘state of exception’ elucidates further why some social groups may be compelled to conceal themselves from the state. Agamben contends that disempowered groups can be simultaneously exposed to the powers of state visualization yet denied entitlements that supposedly come with inclusion in the political order. This disjuncture can be particularly acute in times of crisis and disorder. Braun and McCarthy (2005) draw on Agamben to show how racially minoritized populations in Katrina-struck New Orleans were at once subjected to the full disciplinary force of the law and

denied basic subsistence needs.

Tensions that accompany the state’s intensifying gaze can be even more pronounced when strategies and techniques developed in EuroAtlantic polities are extended to nations in the Global South. For postcolonial nations, resources for rendering people and things legible are often restricted. At the same time, colonial legacies of coercion and violence increase the likelihood that minoritized groups will be targeted by state power, but provide an unlikely platform for encouraging people to take on the mantle of self-monitoring. Consequently, Li contends, state-driven expert discourse in less-developed regions has high probabilities both of falling short of their ambitions and of inciting their subjects to defy governmental authority (2007, p.122).

The purpose of this paper is to interrogate the role of invisibility in hindering progress towards meeting the challenge of understanding and responding to CHR whilst attending to the implications of being seen by the state. First, we evaluate how interrelated forms of invisibility result in systematic biases in researchers’ and decision-makers’ understandings of CHR. In other words, how deficiencies in simplified representations of realities (‘facts’) may prevent states from seeing the full extent of CHR for vulnerable populations. We demonstrate linkages between invisibility and social marginalization and show how invisibility mediates understanding of CHR. This contrasts with other invisibilities which strongly shape the legibility of health risks to state actors yet have rarely been scrutinized through an invisibility lens. Our second objective is to argue that these persistent invisibilities need to be understood through examination of their underlying causes – which resonate with scholarship on health inequities – rather than viewing them as haphazard blindspots in scientific and state knowledge.

Our third intention is to analyze the tensions between the benefits of rendering CHR visible and the risks or drawbacks of exposure to the state’s gaze. From this point emerges part of this paper’s thesis; ensuring justice for those facing the greatest threats from climate change is a moral imperative for governments, and acting on this requires unbiased understandings of these risks. Writing on the state’s role in producing property and citizenship in postcolonial contexts, Lund and Eilenberg (2017, p.52) argue that visibility is fundamental to even the ‘right to have rights’. Political invisibility hinders struggles for citizenship as a mechanism for social inclusion of rights-bearers (p6). However, production and distribution of CHR knowledge can expose the marginalized to unwanted state attention, compromising the invisibility of those relying on hiding. A compromise, we argue, is to respect the politics of hiding whilst tackling the underlying root causes of invisibility. Fostering social accountability, particularly of health systems, and empowerment of the marginalized is one promising route forwards because it enables a ‘reaching’ for power by citizens which can potentially reduce and counterbalance the risks of state legibility. Hence, we propose that the disturbances effected by climate change could actually open up opportunities for afflicted and marginalized communities to make strategic claims of the state. Thus, the formulation ‘(in)visibility’ indicates that visibility and invisibility are not starkly opposed predicaments so much as strategic possibilities that active subjects can alternate between or combine.

2. Inter-related forms of invisibility and linkages to climate-health risks

To show how invisibilities lead to under-estimating CHR and current disease burden, we identify six forms of invisibility that cover the socio-political and scientific domains (Fig. 1). For each, we examine, what is rendered invisible and to whom, and analyze invisibility mechanisms linking climate and health. We identified these six inter-related ‘blind-spots’ by drawing on our collective experiences in Latin America, with geographic and disciplinary breadth (human geography, migration studies, demography, climate science), consolidated during research workshops. Through our discussions, it became apparent that formal and informal institutions underlie climate-health invisibilities

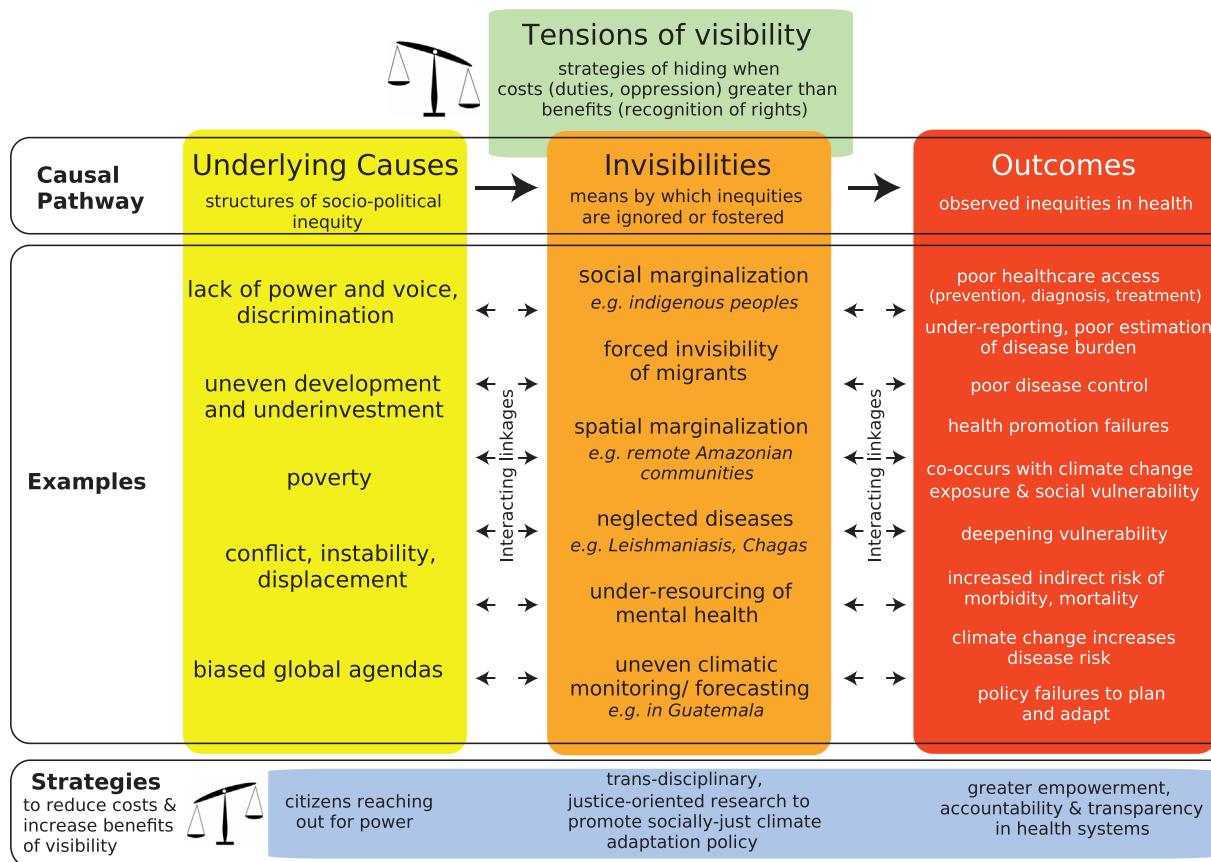


Fig. 1. Conceptual model showing how six inter-related forms of invisibility (shown in orange) cause systematic biases which contribute to the health risks (and appreciation of impacts already experienced) from climate change being under-estimated, misunderstood, exacerbated or ignored (red). The underlying causes of these invisibilities (yellow), are the outcomes of context-dependent structures of socio-political inequalities and associated hierarchies. Strategies (blue) are proposed to tackle underlying causes of invisibility and reduce the tensions of being visible. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

and mediate their effects on CHR awareness or (in)action by researchers and decision-makers. This leads to our more critical analysis; strategic biases in understandings of invisible CHR are not ‘merely’ effects of knowledge-gaps but result from power imbalances. States and their institutions have less interest in ‘seeing’ certain kinds of communities or their diseases (i.e. strategic neglect), while disempowerment compels others to remain invisible (i.e. strategic hiding under pressure). Our experiences support the perspective that health is socially-constructed through conditions of life, birth and death (Curtis, 2004) and reflects structural forces – including political economy and justices/injustices (Venkatapuram, 2010). These forces can only be meaningfully understood through consideration of geographic and socio-political context. Our paper keeps alive the warning that “social injustice is killing people on a grand scale” (WHO, 2008). This speaks to a political ecology of health (PEH) and associated discourses; structural forces produce disease (King, 2010).

Our paper advances Social Determinants of Health (SDH) and PEH scholarship through a three-step analysis (how diverse inter-related invisibilities lead to systematic biases in risk assessment; the causes of these invisibilities; and the necessity of tip-toeing forward), showing that structural forces both shape the (in)visibility of CHR and determine the benefits of becoming visible. The invisibilities we discuss go beyond the macro-scale socio-political-economic contexts used in SDH frameworks by way of our explicit accounting for invisibility related to marginalization. This includes being obliged to hide from authorities, spatial inequalities, selective privileging of diseases and blind-spots in climatic monitoring and forecasting. Finally, our approach complements SDH literature by not only focusing on how marginalization

produces disease but on how marginalization renders health-risks invisible.

Invisibilities have dramatic consequences for health and welfare of marginalized Latin Americans in times of climate change, persistent inequity, socio-political turmoil, and their responses. Our approach is holistic, considering this marginalization can relate to race, social class, locality, migration, and physical or mental health-status. The examples we present support Agamben's notion of states of exception. Marginalized communities can be doubly disadvantaged: first through denial of entitlements that come from inclusion in the political order; second by finding themselves at the sharp end of aggressive governmental responses to climate-induced disorder.

2.1. Social marginalization

The lives and concerns of marginalized populations are relatively invisible to governments and wider society, especially in contexts of high social inequality. Scholarship on race discrimination has demonstrated how the rights, risks, and health of black, indigenous, and other ethnic minorities can be invisible to government (Noguera et al., 2013; Pettit, 2012), including within health systems (Bastos et al., 2018). Unsurprisingly, this invisibility is laid bare when marginalized populations experience climate-disasters (Braun and McCarthy, 2005). Social marginalization also relates to legal status (especially relevant for undocumented migrants and displaced populations), cultural identity, language, age, sexuality, class, caste, profession, gender, and disability (Wolbring and Leopatra, 2012). Invisibility of social groups, such as US Latino populations, generates disregard for their livelihoods, histories,

and diseases, and creates discourses that promote their criminalization (Flores-Yeffal et al., 2017). Health services are broadly culpable of failing to see and act upon the social dimensions of health, as demonstrated by Malatzky and Bourke's (2017) rural Australian case study on intimate partner violence.

Lack of social recognition renders the marginalized more vulnerable to climate shocks and stressors. Turner et al. (2008) show that First Nation communities in Canada experience climate change losses including loss of culture, language, lifestyle, identity, and self-determination that are neither easily quantified nor generate political interest. This everyday invisibility sits awkwardly with the visible role of indigenous peoples as poster-children of fund-raising and climate injustice (Rudiak-Gould, 2013). Furthermore, women's invisibility in fishing and other sectors results from gendered social expectations, leading to underestimation of climatic threats to women's health, well-being, and social relations (Shaw et al., 2015). This reinforces claims that social relations produce individuals and social groups as (in)visible in complex, multifaceted ways (Hole et al., 2015).

Holston's (2008) work in Brazil shows how marginalized people experience differentiated citizenship and it follows that social gradation of rights amplifies CHR. Manderson et al. (2009) demonstrate how healthcare access is constrained by poverty and inequality, and shaped by structural factors such as ethnicity. In low and middle-income countries, it is rare for poor people to have access to good healthcare, and their diseases often go undiagnosed or untreated (Kruk et al., 2018). Using surveys in Buenos Aires, Mexico City and Santiago, Romero-Lankao et al. (2014) found that poor, marginalized people are likely to lack key registrations necessary to access public services, while linguistic barriers, restricted mobilities, and poor information access further impinge healthcare access and behavioural responses to climate extremes.

Multi-country evidence shows that lack of trust in health systems discourages healthcare-seeking behaviour (Kruk et al., 2018). Low trust may emanate from discrimination against minority groups by healthcare providers. For instance, research in Guatemala reported discrimination of indigenous people in healthcare facilities, ranging from indifference to violence, coercion, mockery and deception (Cerón et al., 2016). Mistreatment was rooted in racism but interplayed with discrimination based on poverty, class, language barriers and gender. Castro et al. (2015) found widespread discrimination of indigenous and afrodescendant women by health providers in Latin America, including patient-blaming, abuse, and disregard of traditional beliefs – which conferred shame, limited access to quality healthcare and deterred healthcare-seeking. Gender discrimination relates to access to diagnosis and treatment, which is linked to disease transmission risks through interplay with 'other axes of power and privilege' (e.g. age, religion) (Theobald et al., 2017). Women experience greater disaster-related health impacts in the Global South, for reasons that include cultural norms that limit their mobility, swimming-skill acquisition, and access to public services (Bradshaw and Fordham, 2014).

Burgard and Chen (2014) show how social inequities underlie systematic biases in health data-quality and hinder reliable estimation of disease burdens including for climate-sensitive diseases. They identify mechanisms including socially-differentiated distribution of disease or birth/death registrations; diagnosis bias due to differential access to quality healthcare; and diagnosis avoidance due to stigmatized conditions or socioeconomic or cultural differences in health-seeking. Thus health measurement is deeply embedded in socioeconomic, political and historical contexts (Krieger, 2011), with under-reporting of disease exacerbated by colonial legacies of privileging scientific ways of knowing. Work with Mayan-speaking indigenous communities in Guatemala shows how other forms of healthcare operating beyond the state can remain unseen (Flood and Rohloff, 2018); reinforcing why state institutions are prone to mis-estimating morbidity, mortality and cause-of-death among disadvantaged groups (Burgard and Chen, 2014).

Social marginalization often co-occurs with exposure to extreme

climatic events. Marginalized people are more likely to inhabit hill-slums or peri-urban flood-prone areas and to settle in informal settlements when displaced, resulting in health risks associated with lack of sanitation, clean water and electricity (Bicknell et al., 2009), and limited healthcare access. In the tropics, the marginalized face CHR from nutritional dependence on rain-fed agriculture and from outdoor work increasing exposure to extreme heat (Watts et al., 2015). Feedbacks occur because ill-health promotes poverty and deepens vulnerability. We consider this tantamount to 'slow violence', that is, "out of sight ... an attritional violence that is typically not viewed as violence at all" (Nixon, 2011, p. 2). This manifests through poor child development and pregnancy outcomes, and reduced productive capacity (Hotez et al., 2008). Poverty, limited healthcare access and poor housing combine with environmental conditions to influence vector breeding – triggering disease outbreaks.

2.2. Forced invisibility by migrants

Many irregular migrants hide from the state, seeking invisibility to avoid arrest, deportation or discrimination. Latino migrants in the USA are relatively well-studied compared to migrant groups in Latin America including undocumented Brazilian gold-miners and sex-workers in the Guianas. Recently, Venezuelans displaced by instability and seeking refuge in neighbouring countries had rights but were hindered from realizing them through 'health coverage limbo' (800,000 migrants in Colombia; (Fernández-Nino and Bojorquez-Chapela, 2018)) or organized violence (Brazilian Amazon; (Andreoni, Manuela, 2018)).

Multi-sited research in the US and Mexico shows that forced invisibility exacerbates family separation, affects mental health (Dreby, 2015) and prevents migrants from sending home remittances. People hiding often lack healthcare access, which is compounded by denied entitlements including welfare benefits, owning a driver's licence, or credit access (Flores-Yeffal, 2013). During fires in California, undocumented workers had limited access to services, feared seeking shelter, and lacked unemployment benefits when laid-off; some were expected to continue night-working despite official smoke hazard warnings (Sesin, 2017). Outdoor labour exposes many Latino migrants to climatic variability (Smith et al., 2014), compounding chronic burdens of work-related injuries (Weigel and Armijos, 2012) and neglected diseases of poverty. Holmes (2006) followed the migration of indigenous Triqui Mexicans in western USA and Mexico, finding that health disparities with other groups were determined by ethnicity and citizenship. Indicative of structural and symbolic violence, each group was understood to deserve its place in the hierarchy.

Hotez (2008) identified huge neglected disease burdens in USA-Mexico border regions, which we suggest are related to forced invisibility. More recent estimates are available for Texas (Hotez, 2018), though many diseases are not-notifiable and hence unreliably recorded. A randomized survey of Mexican-American families in El Paso, Texas (De Heer et al., 2013) did not ask about migration status, yet provides clues related to undocumented migrants' health-determinants. El Paso has a large foreign-borne population (27% in 2016), around one-quarter of whom may be undocumented (Pew Research Centre; <https://www.pewhispanic.org/interactives/unauthorized-immigrants-by-metro-area-table/>). De Heer et al. (2013) found similar factors shaped ill-health and barriers to healthcare. These included financial constraints (inability to pay medical costs related to income and lack of insurance), along with transportation difficulties, misunderstanding of medical information, and disrespectful treatment in medical settings. Weigel and Armijos' (2012) research in El Paso and New Mexico found that migrant farm workers struggled to access healthcare due to out-of-pocket costs and the expense of missing work.

Lack of healthcare access by undocumented migrants results in under-diagnosis, poor disease control from lack of treatment, and under-reporting. For instance, Brazilian gold-miners are a "hidden but critical malaria reservoir" in French Guiana and self-treatment risks

raising anti-malarial resistance (Douine et al., 2016). Censuses generally miss irregular migrants, leading to highly inaccurate population size estimates (Passel and Cohn, 2016). Undocumented immigrants also are more likely to live in segregated communities, be exploited, and live in poverty. Isolation prevents local language learning and restricts access to education and other governmental resources (Flores-Yeffal, 2013). Overall, forced invisibility leads to under-estimation of CHR and deepens health vulnerabilities.

2.3. Spatial marginalization

Spatially-uneven development means that certain kinds of people and places are systematically neglected. This translates into elevated vulnerability to climate change (Parry et al., 2018) and under-estimation of climate-health linkages, exacerbated by the relative invisibility of rights, health risks, hazard exposure and social and infrastructural vulnerability. Inadequate healthcare access in marginalized regions, provincial towns, and rural areas compromises prevention, diagnosis, and treatment of climate-sensitive and co-occurring diseases (Fig. 1). Braun and McCarthy (2005) argue that although political invisibility makes marginalized communities more vulnerable to climate disasters, these events provide a 'shock of recognition', rendering visible and undeniable long-standing state abandonment. However, is lasting political recognition likely in contexts that national/international decision-makers, media and citizenry neither know of nor care about? Woefully inadequate governmental responses to Katrina and resultant consequences for minoritized communities was certainly remarkable, but was similar political scrutiny applied to the destruction of 17 neighbourhoods and 300 deaths following a landslide in Mocoa, Putumayo in Colombian Amazonia in 2017? Kaijser and Kronsell (2014) provide conciliation by concluding that, depending on the socio-political context, climate change can either reinforce power structures and social categorisations, or see them challenged and renegotiated.

Healthcare access and quality is highly spatially uneven in Latin America (Fullman et al., 2018). Brazil's Amazonian North has 1.1 medical doctors/1000 inhabitants, compared to 2.8 in the richer South-East, plus a metropolitan bias in Amazonas state with 2.8 doctors/1000 residents in Manaus compared to 0.2 in towns with < 50,000 (Scheffer, 2015). Children's healthcare is particularly patchy. Amazonas State covers 1.6 million km² and has 3.8 million people, yet only 344 paediatricians, overwhelmingly located in the state capital (Fig. 2a). The

North also has low access to mental healthcare (Fig. 2b); 1 psychiatrist/80,000 versus 1/15,000 in the South-East. Parry et al. (2018) showed that pregnant women in remote or road-less Amazonian municipalities receive less antenatal care. Remote rural settlements in Amazonia receive particularly poor healthcare - they are less likely to have Community Health Agents and urban visits are infrequent (Parry et al., 2010).

Spatial differences in ill-health reporting reflect deficient healthcare access and research gaps, leading to underestimation of disease burden and CHR biases. For example, flood exposure increases risks of diarrhoeal disease in Amazonian riverine communities (Fonseca et al., 2016), yet studies relying on hospitalization records underestimate morbidity (do Carmo et al., 2011) where remoteness leads to home treatment. Indeed, WHO (2014) estimates of climate change's disease burden to 2050 do not account for river-flooding's enormous health-risks. A recent study predicts up to 20,800 worldwide annual fatalities from river floods under global warming, reflecting an increase in annual exposure from 58 million people to over 240 million (Dottori et al., 2018). Additionally, disease burden metrics require reliable prevalence estimates, often unavailable for vulnerable regions. For instance, mental illness burdens for the North of Brazil are calculated using prevalence rates from the South (Bonadiman et al., 2017), whose development stage, health profile, and healthcare access contrasts drastically.

Major climate-health research gaps exist for marginalized regions like Amazonia (Brondizio et al., 2016) and informal urban settlements (Romero-Lankao et al., 2014). Emblematic of the former is the invisibility and neglect of chronic under-nutrition and high intestinal parasite burden among non-tribal children in areas of Amazonia with little healthcare or sanitation (Silva, 2009). Multiple invisibilities intersect because marginalized groups such as indigenous populations tend to inhabit remote places (Parry et al., 2018) and face growing exposure to climate hazards (Duffy et al., 2015). At local scales, poorer populations are priced out of many areas and pushed to places at risk from floods and landslides (Romero-Lankao et al., 2014). Frequently, these places lack infrastructure, healthcare, community organizations and other safety nets needed to protect health, houses and belongings from climate hazards. In our experience, disease control is generally inferior in marginalized, under-resourced places. Overall, CHR emerge from high social vulnerability and previous extreme event impacts, which may be underestimated or ignored by decision-makers due to

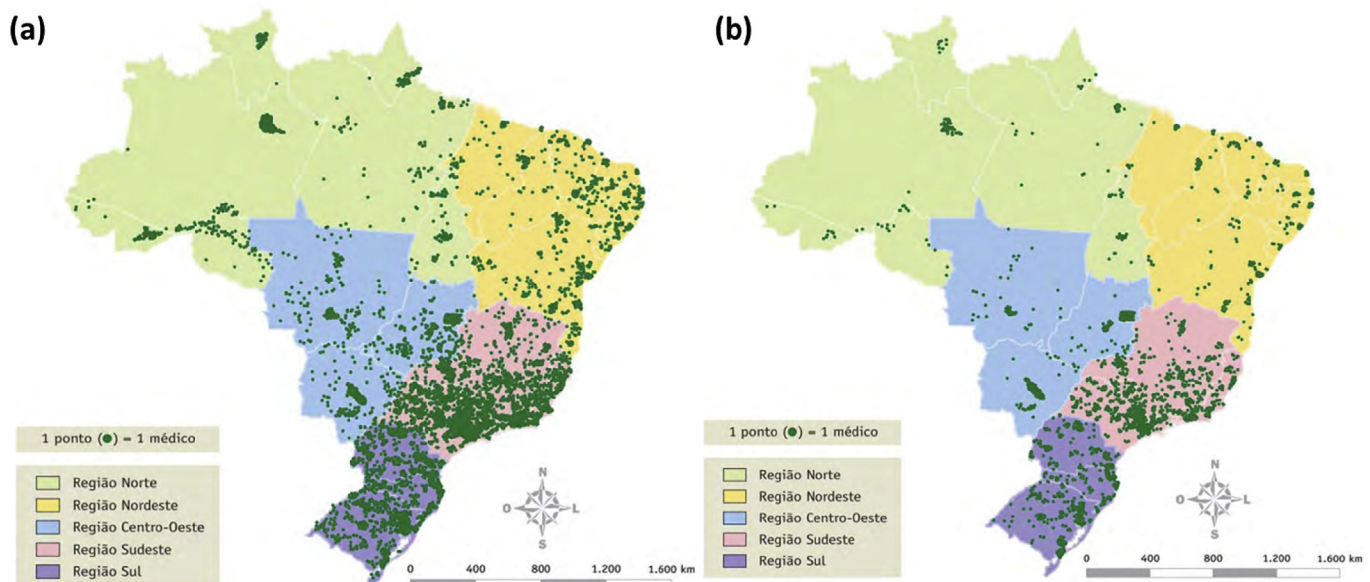


Fig. 2. Geographical distribution of (a) paediatricians and (b) psychiatrists in Brazil. Reproduced, with permission from Scheffer (2015).

spatial invisibility.

2.4. Neglected diseases

Neglected diseases (NDs) are intimately linked with poverty and disadvantage (Manderson et al., 2009) and have strong yet relatively overlooked interactions with climatic change (Fig. 1). These diseases affect marginalized populations with low visibility and little political voice; cause stigma and discrimination; impact mortality and morbidity; are relatively neglected by research; but can be controlled and prevented using effective and feasible solutions (Barry, 2014). Hofstraat and Brakel's (2016) review finds that NDs exert heavy social and psychological burdens and are associated with social exclusion, reduced quality of life and poor mental health. Intersectionality is essential for understanding and alleviating the burden of NDs (Theobald et al., 2017). Intersectionality is a theoretical perspective that emphasizes ways in which myriad systems of inequities work with and through each other, at multiple social scales (Bastos et al., 2018).

Recent decades have seen progress in ND control and elimination (e.g. <https://unitingtocombatntds.org/>) due to increased policy attention and funding, NDs now constituting an official SDG target (Engels, 2016). Following the 2012 London Declaration on NTDs, pharmaceutical companies pledged to provide free medicines, (Molyneux et al., 2017). Yet changes in the global prevalence of 26 NDs between 1990 and 2013 indicate modest success (Herricks et al., 2017). There were still 2.482 billion annual cases in 2013, and although the median change (over 23 years) for specific diseases was negative (−5%), 11 NDs became more prevalent. Molyneux et al. (2017) reported that progress has been limited in areas of conflict and for remote populations far from power centres. This is congruent with work in Brazil, finding that although annual ND-related mortality declined by 2.1% from 2000 to 2011, annual rates increased by 3.6% in Amazonia (Martins-Melo et al., 2016a).

By definition health consequences of NDs are relatively invisible to decision-makers, leading to failures in prevention, diagnosis, treatment, control, and reporting (Herricks et al., 2017). Some NDs are climate-sensitive, others predispose at-risk populations to climate-related morbidity and mortality. NDs have co-morbidity with other climate-sensitive public health problems (e.g. malnutrition, malaria, diarrhoeal disease, violence) (Manderson et al., 2009). For many NDs lack of reliable population-based prevalence estimates and burden data constrains mitigation through vaccines, vector control, public health or treatment. Most are not reportable to the CDC (<https://www.cdc.gov/nndss/conditions/notifiable/2019/>) although may be reportable in specific states (e.g. Chagas in Texas (Hotez, 2018)) or Latin American countries (e.g. leishmaniasis, Chagas, schistosomiasis in Brazil: http://bvsm.s.saude.gov.br/bvs/saudelegis/gm/2017/prc0004_03_10_2017.html). Indicative of information gaps in the US, government-reported records of dengue are only in the hundreds, despite evidence of autochthonous transmission (Guzman and Harris, 2015; Hotez, 2018).

Latin American funding, policy, and research in has prioritized HIV/AIDS, tuberculosis, and malaria, contributing to failures in controlling NDs. Our analysis of Global Burden of Disease data (GBD, 2016) shows the total burden of NDs in Latin America is very high, but less than the 'big 3' combined due to high HIV/AIDS burden (Table 1). NDs cause 135 DALYs/100,000 people, 49% higher than tuberculosis and 84-times greater than malaria. NDs with the greatest burdens in Latin America are Chagas, dengue and acariasis, which are 18, 14 and 9-times greater than malaria, respectively. Mortality data from Brazil further emphasizes the impacts of NDs (Martins-Melo et al., 2016b); Chagas killed 4911 people annually over 2000–2011, similar to tuberculosis (4,940). Malaria deaths were much lower (107) than for Chagas and four other NDs. Invisibility of ND risks, burdens and climate-linkages hampers efforts to track health impacts of climate change. Indeed, many diseases targeted by the Lancet's *Countdown* (Watts et al., 2017) are heavily under-reported due to healthcare barriers arising through the interplay

Table 1

Burden of Neglected Tropical Diseases (NTDs) in Latin America (LA), based on Disability-Adjusted-Life-Years (DALYs) per 100,000 population. Data are from the GBD (2016), extracted from IHME. Burden is also shown for the 'big 3' diseases, with a column indicating the burden of diseases relative to malaria. Note that all data are the rates averaged across 4 sub-regions; Mexico; Tropical LA; Central LA; Southern LA.

Disease	DALY rate	Malaria multiplier
Chagas disease	29.0	18
Dengue	21.8	14
Ascariasis	13.8	9
Trichuriasis	13.0	8
Hookworm disease	12.3	8
'Other' NTDs	12.2	8
Schistosomiasis	9.9	6
Cysticercosis	9.2	6
Leishmaniasis	6.3	4
Food-borne trematodiasis	3.0	2
Yellow fever	2.3	1
Trachoma	1.8	1
Cystic echinococcosis	0.46	0.29
Onchocerciasis	0.04	0.03
Rabies	0.02	0.01
Lymphatic filariasis	0.00	0.00
African trypanosomiasis	0.00	0.00
Total for NTDs	135.0	84
<i>Non-neglected diseases:</i>		
HIV/AIDS	222.5	139
Tuberculosis	90.8	57
Malaria	1.60	1

of NDs with socio-spatial marginalization. Shockingly, Den Boer et al. (2011) estimate over half of people infected with leishmaniasis globally lack appropriate diagnosis and treatment.

Houweling et al.'s (2016) global review found persistent socio-economic inequalities in ND distribution, often with twice the odds of infection among poor and less-educated people. NDs link to social marginalization in Latin America by affecting mainly indigenous, poor, and rural populations and people of African origin (Hotez et al., 2008). Marking profound inequality, 62% of people living with Chagas in Latin America are in middle-income countries; Argentina, Mexico and Brazil (Hotez, 2015). Diseases are more likely to be neglected when they affect those living in marginalized places within countries. In Amazonia, poor healthcare access worsens the burden of Chagas, helminth infections, trachoma, and leishmaniasis (Hotez et al., 2008). Furthermore, NDs such as helminth infections, caused by poor sanitation and associated with rural poverty, disproportionately affect indigenous Amazonians. With intersectionality of socio-spatial marginalization and remoteness, Amazonia is a ND global hotspot (Hotez, 2014).

Climatic change affects ND transmission, although research is lacking (Molyneux et al., 2017). Dengue-climate linkages have received increased attention, and models indicate that changes in temperature and precipitation will shift geographic ranges and abundance of *Aedes* mosquitoes (Ebi and Nealon, 2016). However, modelling studies inadequately account for how future dengue burden will be shaped by interactions of climatic change with shifting human population distributions, human movement and shipping (Morin et al., 2013). Waterborne diseases are major causes of morbidity and mortality among infants through diarrhoeal disease, and increase after heavy rainfall and flooding (Levy et al., 2016). A study of an Amazonian state capital Rio Branco found 7% increases in hospitalizations for infectious diarrhoeal disease for a one-metre increase in river levels (Duarte et al., 2017). Health impacts from flooding are diverse (e.g. mental disorders, respiratory infections, leptospirosis, healthcare disruption (Paterson et al., 2018), and mediated by social disadvantage.

Action to prevent ND transmission – investments in sanitation, vaccination and public health – remains woeful. Only 0.6% of official

development assistance for health is spent on NDs that collectively affect over one billion people (Liese et al., 2014). NDs are poverty-promoting due to treatment costs and lost-labour - therefore if climatic shocks increase ND prevalence, deepening poverty and vulnerability to other climate-linked disease may follow. Chronic infections- including helminths and skin parasites - cause life-long disadvantage by impairing growth, learning, productivity, and pregnancy outcomes (Hotez et al., 2008). Discrimination prompts ND-infected individuals to hide their condition (e.g. Chagas in Argentina) (Auger, 2012).

2.5. Under-resourcing of mental health

The global burden of mental health conditions is vast, estimated to constitute 32% of years lived with disability (Vigo et al., 2016). However, burdens are complex and poorly understood, particularly in the Global South (Nguí et al., 2010); and related CHR remain largely hidden. Evidence suggests that climate-shocks increase the prevalence of common mental disorders, despite political and research bias towards economic and physical health impacts (Berry et al., 2018). An extensive US study analysing linkages between weather and self-reported mental disorders (Obradovich et al., 2018) found that exposure to hotter temperatures, higher rainfall and cyclones all impacted mental health negatively. Extreme climatic shocks can constitute disasters, which Neria et al. (2008) define in health terms as collectively experienced mass traumas. Tsunamis and other non-climatic disasters (can increase rates of major depression and post-traumatic stress (Fergusson et al., 2014; Van Griensven et al., 2006). Research following Hurricane Sandy found that mental health-risks were differentiated for specific populations and communities (Neria and Shultz, 2012); supporting an intersectionality approach. Climatic change - abrupt and gradual - also impacts well-being and livelihoods through damage to physical and social environments (Berry et al., 2010). These stressors can cause depression, anxiety, and post-traumatic stress (Wilcox et al., 2015). Evidence is scarce, however, and a global review of flooding and mental health found only one longitudinal study with a baseline and control group in the global North and none in the South (Fernandez et al., 2015). Irrefutably, research into mental health dimensions of climatic change in Latin America is lacking. One exception is a study on the impacts of Hurricane Mitch (1998) which found people living in high-impact areas in Honduras suffered greater levels of distress, grief and post-traumatic stress (Kohn et al., 2005).

Little epidemiological evidence exists for mental health effects of sub-acute weather events. However, work in Australia shows that drought exposure increases suicide risk among rural males 30-49 y by 15% (Hanigan et al., 2012). Loring and Gerlach's (2009) review found indigenous Alaskans experiencing climate stressors worry about food, linked to hunting practices and gender role impacts, and risk of alcoholism. The marginalized experience greater psychosocial risk from disasters (Neria et al., 2008), with people lacking legal status particularly vulnerable to chronic mental health conditions due to state persecution/neglect, unemployment and poverty, violence, and discrimination (Dreby, 2015; Flores-Yeffal, 2013). Climatic extremes also increase mental health risks if they precipitate population displacement and migration (McMichael et al., 2012). Encouragingly, mental health risks are now recognized by climate scientists and the IPCC (Smith et al., 2014, p.732), yet tracking ability is limited (Watts et al., 2017).

Latin American mental health is under-resourced, with 9 workers/100,000 people, compared to 125/100,000 in the US (Kohn et al., 2018). Building capacity for mental health services is constrained by low research capacity, stigmatization of mental illness and insufficient funding. Development assistance for mental health is only US\$0.9/DALY compared to US\$144 for HIV/AIDS or US\$32 for tuberculosis (Charlson et al., 2017). These factors explain treatment gaps in Latin America, which are 70% for severe mental illness (e.g schizophrenia), and 84% for substance-use disorders (Kohn et al., 2018). Across five Latin American countries, on average only 9% of people with

depressive disorders received minimally adequate treatment, from 1% in Peru to 18% in Argentina (Thorncroft et al., 2017).

Optimistically, Watts et al. (2017) state, "government and agencies now emphasise psychological and psychosocial interventions within disaster response ..." However, does this apply where there are virtually no mental health services? Researchers may have been seeing the tip of the iceberg in terms of complex linkages between mental health, climate change and other invisibilities. For instance, mental health has comorbidity with many climate-sensitive NDs, impacting on the psychosocial status of individuals and households through depression and anxiety - affecting patients and caregivers (Ton et al., 2015). Geographical accessibility to primary care is an important determinant of mental health (Allen et al., 2014), hence there are linkages between under-resourcing of mental health and spatial marginalization. This review concludes that disasters compromise service delivery to those with pre-existing mental health conditions, worsening symptoms. Even discounting climate change, many developing country health systems don't routinely collect mental health data - limiting burden estimation and effective planning (Nguí et al., 2010).

2.6. Uneven climatic monitoring/forecasting

Identifying climatic variability and change (CVC) is helpful for understanding and mitigating CHR (but see Section 4). Effective intervention requires reliable and accessible monitoring and early warning systems (Mayhew and Hanefeld, 2014; UNEP, 2012). However, deficiencies in monitoring CVC combine with those in health surveillance and vulnerability to render CHR invisible.

Information and communication technologies have advanced CVC assessment, exemplified by the Latin America Flood and Drought Monitor (<http://stream.princeton.edu/LAFDM/WEBPAGE/index.php>). However, fragmented environmental monitoring for many areas, due to conflict, deficient infrastructure, or insufficient human capital, limits CVC understanding. Records may be too patchy to allow reliable estimation of long-term trends or extreme events. Identifying CVC occurrence (timing, duration, severity) requires local-scale data analysis of temperature, rainfall and river-levels. Importantly, assessments should account for vulnerability-determinants such as local-scale service quality or reliability (e.g. water supply in Mexico City (Romero-Lankao, 2010)). Vital are reliable indicators of social sensitivity and assets that invisible people may draw on (e.g., warning systems, shelters) during climate-disasters.

Shortcomings in scientific monitoring of CVC and vulnerability are exacerbated by predominance of technocratic ways of knowing. Climatologists generally consider climate change to be too big, slow or uneven to be 'visible', but as *visualizable* (i.e. can be made seeable) through instrumentation and analysis (Rudiak-Gould, 2013). Yet instrumentation is unable to capture climate change occurring everywhere. Furthermore, though Swim et al. (2009) contend that people do not directly experience climate change, it is visible to rural populations across the Brazilian Amazon (Dubreuil et al., 2017), and elsewhere, by "well-educated members of frontline indigenous communities [that are] outspoken visibilists" (Rudiak-Gould, 2013). Earlier examples (Loring and Gerlach, 2009; Turner et al., 2008) demonstrate how prevalence of positivistic, epidemiological explanations for disease underlies climate-health invisibility. Epidemiology frequently ignores socio-political determinants and produces explanations limited by data availability, ignoring social practices, values, and risk perceptions. Put differently, it excludes 'metis', valuable experiential knowledge embodied in local practices (Scott, 1998, p.6). This can be explained in terms of a general tendency of governmental expertise to overlook and override more fine-grained, place-based and differentiated know-how. But we can also view it as symptomatic of missed opportunities for opening up two-way traffic in CHR legibility and for instituting mutual learning processes (see Barnett and Scott, 2007).

Climatic-disaster early warning systems in Latin America have major

geographic gaps, including inadequate flood warning and monitoring in Guatemala, Honduras, Nicaragua, and Brazil (UNEP, 2012). Connected health risks become invisible to decision-makers when systems do not provide timely, reliable, and actionable warnings. Overall, stronger inter-institutional links are required to ensure integration of data-collection with information delivery and user response (UNEP, 2012). General Circulation Model (GCM) climate predictions are spatially coarse and narrowly quantitative, unable to account for variable governance, sociocultural specificity or local heterogeneity in hazard exposure. Reliance on global modelling limits potential for assessing, planning and preventing regional-level health impacts (Brondizio et al., 2016). In Amazonia, drought and flood forecasts are at spatial scales and resolutions irrelevant to local communities and are generally disconnected from livelihood needs (Brondizio and Moran, 2008). Effective provision of climatic information is compromised by divergent knowledge systems, language and terminology and the lack of credibility to smallholders and others. In Guatemala, droughts repeatedly affect rain-fed agricultural areas, yet spatial data gaps constrain insurance index development for climate-risk management (Jensen and Barrett, 2017).

Climatic monitoring/forecasting failures interact with spatial marginalization and health-research gaps. Romero-Lankao et al. (2012) analysed case studies from 222 cities and found few Global South epidemiological studies on extreme temperature vulnerability (Fig. 3) and broad failures to account for socio-political processes. Hence, climate-health links are underestimated or ignored at local scales, contributing to poor governmental planning. This invisibility constrains efforts to track and reduce climate-impacts including the *Lancet Countdown* (Watts et al., 2017), which relies on accurate measures of flood and drought exposure and reliable observational health data. A climate-health forecasting platform with fine spatial resolution exists for malaria (e.g. ENACTS in Africa, <https://iri.columbia.edu/resources/enacts/>), although lack of ground-based weather monitoring in some areas limits such systems (UNEP, 2012). Remote sensing is not a panacea for reliable climatic monitoring/forecasting because instrumental data are required to validate satellite-derived products and for measuring model uncertainty. Moreover, surface-based *in situ* measurements input to generating seasonal forecasts because they provide local estimates of variability not captured by GCMs.

2.7. Section summary

We draw four conclusions here. First, there is strong evidence that

invisibilities underscore systematic biases in scientific and political understandings of CHR, resulting in inadequate healthcare surveillance and treatment, and deepening of vulnerability and disease burden. These blindspots persist because marginalization results in particular kinds of places, diseases, communities - and their amplified CHR - falling outside the political gaze and being neglected by researchers. Marginalization also connects to NDs, characterized by unreliable burden estimation. Together, these invisibilities underscore systematic failings in Latin American health surveillance, leading to under-estimation of CHR and failures to control climate-sensitive and co-occurring diseases. Invisibilities also weaken health promotion, whose normative goal of achieving health equity by “enabling people to increase control over their health and its determinants” (WHO, 2005) requires reliable evidence for evaluating implementation. Our findings echo Potvin and Jones’ (2011) assertion that health promotion’s expansion beyond high-income countries has been curtailed by insufficient evidence for those policies implemented and inadequate in-country capacities.

Second, quality of evidence available to interrogate specific biases in climate-health research is mixed and major research gaps remain. There is strong, critical scholarship on social determinants of health, some progress in confronting the neglected diseases, and increasing (albeit insufficient) attention being paid to mental health risks from climatic change. We found less analysis of CHR - or examination of existing knowledge gaps - for migrant populations and spatially-marginalized places, including blindspots in reliable climatic monitoring/forecasting. Overall, most relevant research is from the Global North (particularly US, Canada and Australia) while Latin American evidence bases are considerably weaker. It is problematic to precisely enumerate the under-estimate of CHR due to systematic neglect by researchers, who are dependent on, and responsive to, political will. Despite technological advances, patchy monitoring and inadequate forecasting curtails attributing health outcomes to CVC. Deficient health and climatic data matters because long-term, high-quality and accessible data are essential for establishing the influence of CVC in disease spread. Linking CVC to health outcomes is challenging due to migration, spatial- and temporal-scales of measurement, time-lags, and seasonal patterns in weather and livelihoods. Gaining comprehensive insights into CHR is also challenging due to ‘unknown unknowns’ from dynamic, uncertain interaction between accelerating environmental change and emerging infections (Watts et al., 2015).

Third, limited governmental transparency in priority-setting, expenditure, disaster management, and health-surveillance (Manderson

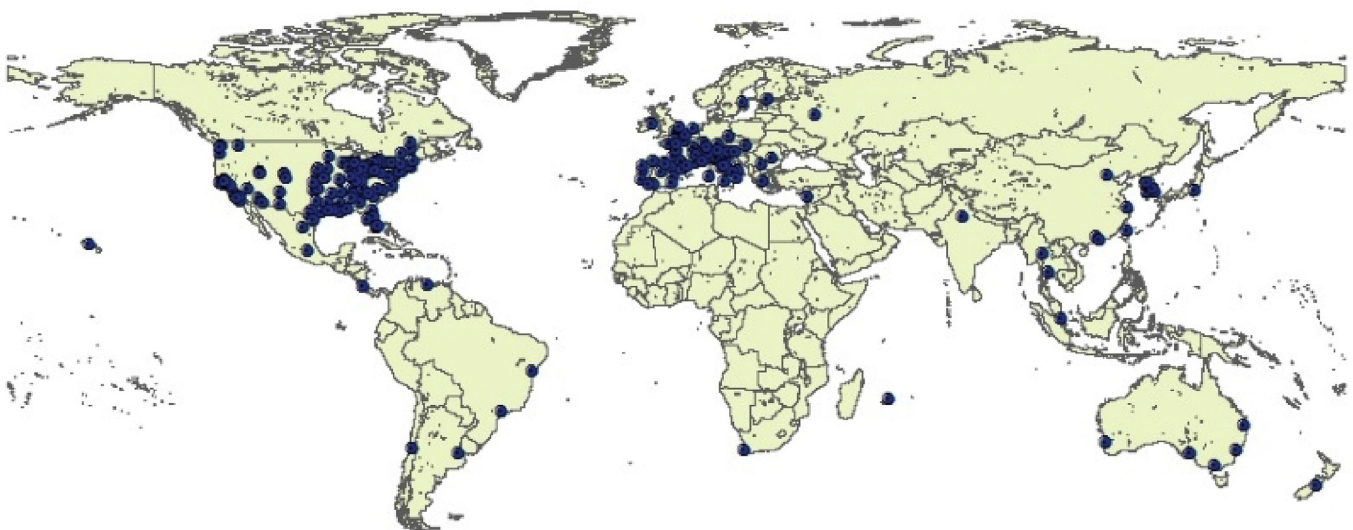


Fig. 3. Locations of epidemiological studies of urban vulnerability to temperature-related hazards. Reproduced with permission from Romero-Lankao et al. (2012).

et al., 2009; Venkatapuram, 2010) frustrates efforts to assess CHR and policy-performance (Watts et al., 2015). Poor quality healthcare follows from widespread failures in public health governance and corruption in many countries (Anti-Corruption Evidence; <https://ace.soas.ac.uk/>) (Mostert et al., 2015; NASEM, 2018). Governance failures pre-empt poor disaster response, and exacerbate the effects of invisibilities but remain hidden by insufficient transparency and low accountability.

Finally, due to evidence of strong, multiple interactions across the six invisibilities there is a compelling case for using intersectionality theory (Hankivsky, 2014) to inform climate-health research. Those at greatest climate change risk face multiple, interacting disadvantages yet decision-makers may overlook their health-risks due to overlapping social, spatial and environmental invisibilities. Frequently used to analyze the multiple, interacting influences of socio-political 'location' and identity, including in a health context (Kapilashrami et al., 2015; Larson et al., 2016), intersectionality is well-suited for examining how combinations of invisibilities (e.g. geographic location, ethnicity, disease, migration status) shape legibility of CHR. Intersectionality could highlight ways in which forms of state neglect or social discrimination vary according to multiple, interacting social positions of individuals. Furthermore, applying an intersectional lens to CHR suggests that not only are disadvantages or socio-political 'locations' intersectional, but so too are the new and unexpected invisibilities resulting from those disadvantages. Hence, applying intersectionality framework helps understand how systems of power in society, and the power structures produced by intersectionality (Osborne, 2015), affect how invisibility is experienced in complicated non-binary ways.

Through their intersecting identities and social locations, individuals can experience invisibilities and visibilities simultaneously, just as they can belong to both oppressed and oppressor groups (Hankivsky, 2014). Intersectional theory encourages climate-health research to explore the interacting dimensions of different sources of invisibilities, rather than approaching them as simply additive or multiplicative. Research could further explore how vulnerability to climate change arises from multiple factors related to social position, disempowerment and oppression (Osborne, 2015; Van Aelst and Holvoet, 2016). Finally, intersectionality helps risk management (Sultana, 2010) address the multiplicity and complexity of human experience in ways that recognize and visualize climate-health vulnerabilities in the lives of all individuals, illuminating pathways for change (Djoudi et al., 2016).

3. Causes of invisibility

Merely considering how different types of CHR go unseen would be not seeing the forest for the trees. Our interest in the underlying causes of invisibilities is inspired by Hicken et al's (2018) work framing structural racism in health as the outcome of cultural racism. Structural racism emerges as institutional practices promoting a myopic focus on behaviours and experiences, failing to situate related inequalities within socioeconomic and political structures. Tunnel vision creates a 'cloak of invisibility', Hicken et al. argue, leading to discriminatory policies that appear overtly neutral and rational. The underlying causes of the invisibilities we identify are the outcomes of these structural inequalities and associated hierarchies (Fig. 1). We contend that (re) production of climate-health invisibilities results from five inter-related problems: lack of power and voice; uneven development; poverty; conflict, instability, and displacement; and biased global agendas. These causes are familiar to researchers interested in social determinants of health (WHO, 2008), yet these structural forces are peripheral to mainstream debates around climate change and health (e.g. Watts et al., 2017).

Lack of voice is cause (and consequence) of marginalization and neglect and correlates with political-economic power imbalances. Recent analysis of subaltern struggles in Brazilian Amazonia shows how misrecognition engenders powerlessness, further silencing marginalized

voices (Fraser, 2018). Farmer (2004) shows how lack of recognition, exemplified by indigenous struggles, results from structural inequalities of concealed power, which is often ignored by international health organizations. The 2007, UN Declaration on the Rights of Indigenous Peoples recognized their rights to health, maintenance of traditional health practices and participation in health institutions. However, in many countries insufficient social, cultural and political recognition explains enduring inequities between indigenous and non-indigenous health (Kirmayer and Brass, 2016). Inequalities are created and maintained through political processes that determine which voices are silenced, and thus governments are arguably the greatest perpetrators of marginalization of people, places, and diseases. Resultant exposure to harm, including through CVC, amounts to structural violence (Galtung, 1969). Power imbalances, stigma and discrimination also underlie neglect of mental health and are embodied in social structures and legislation (Henderson et al., 2014). Imbalances of power and resources are indeed central to WHO's (2008) conceptualization of structural health determinants.

Truths constructed through the media, political and organizational processes, and power structures can make CHR less visible, including through media absence in remote places and digital divides (Flores-Yeffal et al., 2017), side-lining of indigenous languages in global health initiatives (Flood and Rohloff, 2018), or organized denial. Active in many countries, denial counter-movements obstruct policymaking by refuting the reality and significance of climate change (Dunlap and Brulle, 2015). Conservative think-tanks and others manufacture – and make visible – scientific controversies and uncertainties in order to render *invisible* climate change and related risks. This is distinct from the socially-organized denial theorized by Norgaard (2012), which is more akin to cognitive dissonance. Her ethnographic research in Norway shows how privileged people draw upon 'cultural avoidance strategies' in separating their climate change anxieties from feelings of guilt or responsibility. Consequently, climate change recedes from daily life.

Uneven development underpins spatial marginalization, NDs, and uneven climatic monitoring/forecasting. Global South governments are often too poor, indebted, corrupt or frail to provide universal health coverage or scientific capacity necessary for effective environmental and health surveillance (NASEM, 2018). These challenges mask climate-health linkages and hamper response to health emergencies. For Marxian geographers, development inequalities are inevitable under capitalism due to spatial marginalization, shaped by underlying political-economic and historical processes which coproduce socio-spatial relations (Gregory and Urry, 1988). These processes create power imbalances that determine impacts of 'natural' disasters (Blaikie et al., 1994). Lower living standards also relate strongly to social marginalization and ND infection. Poverty is a direct mechanism through which the marginalized experience greater health risks and worse healthcare access (Marmot et al., 2008).

Poverty arises from uneven development at macro-scales, although poor populations experience inferior healthcare even in middle- and high-income countries, (Kruk et al., 2018; Peters et al., 2008). Inadequate healthcare is related to poverty and marginalization, reflects social invisibility and perpetuates CHR neglect. Uneven development is also associated with political instability and conflicts that exacerbate climate-health invisibilities by disrupting health systems, triggering disease outbreaks and involuntary displacements, and pushing vulnerable populations deeper into poverty (Gleditsch, 2012).

Biases in global health agendas underpin the invisible burden of NDs and reflect imbalances in voice, power, development, and capital. The Global South and poorer populations elsewhere, often migrants, bear the brunt of NDs yet lack power to attract policy attention and funding. Health resources are often focused towards epidemics rather than endemic diseases, and conflicts of interest and accountability can surround the former (Peters et al., 2017). Relative disease importance is negotiated and many climate-sensitive or co-occurring diseases are

neglected and under-resourced. Bhattacharya et al. (2005) argue that advocacy, media, finance, philanthropic interests, and international organizations determine disease visibility, which then affects disease control budgets. They show how platforms seeking universal policy solutions exacerbate neglect, silencing local contexts and agendas. Neglect of mental health is equally problematic, receiving only 0.4% of development health assistance (Vigo et al., 2016).

How different underlying causes shape invisibility is context-dependent, as is all health. Allen et al. (2014) conclude that mental health is strongly shaped by people's living conditions, which arise through past and present interplay of political, economic, cultural environmental and social factors. Berry et al. (2010) demonstrate how the same factors determine how climatic disasters impact physical and mental health.

4. Tackling invisibility?

Here, we grapple with tensions around whether or not increasing the visibility of CHR benefits the most vulnerable. Understanding people's relationship with the state is central to understanding these tensions, the state being, "*the vexed institution that is the ground of both our freedoms and our unfreedoms*" (Scott, 1998, p. 97).

4.1. The case for visibility

One the hand, increasing visibility of CHR is desirable – and just – because it may inform interventions designed for their mitigation. This perspective is supported by evidence presented in Section 2. Greater visibility of the marginalized potentially enhances societal recognition of disadvantage, catalyses improvements in access to quality healthcare, improves disease-burden estimation, and reverses neglect by researchers and governments. Indeed, societies may have a moral responsibilities to act because invisibility exacerbates already inequitable burdens of climate-related disease and other environmental injustice. Seeing, understanding and acting to reduce CHR can therefore be framed around justice. Health is a moral entitlement through the ability to achieve vital goals (Venkatapuram, 2010); ill-health can engender lifelong and inter-generational disadvantage (Huang et al., 2011). To ensure inter-generational fairness, therefore, necessitates tackling health inequities – including those exacerbated by climate change, to '*ensure healthy lives and promote well-being for all at all ages*' [SDG 3]. Tackling invisibilities could underpin the "*concerted public policy*" which Watts et al. (2017) consider necessary for seizing climate change as an "*opportunity to improve global health*".

We found poor healthcare access and quality an important consequence of invisibility. Achieving universal healthcare requires higher, more equitable spending in many countries (WHO, 2013) and systemic change to monitoring and reporting (Kruk et al., 2018). Global health priorities need overhauling to alleviate burdens of NDs and health disadvantages that accumulate over the life-course for marginalized, irregular, and other invisible populations. Overall progress is insufficient since Manderson et al.'s (2009) recommendation that equity should motivate policy and legislation, research, resourcing, project implementation, and monitoring. Continued increases in funding for NDs would enable mass drug administration, better diagnosis and reporting, treatment, and transmission control. A justice perspective demands engagement with underlying causes of marginalization and scientific blindspots, rather than sticking plasters. This means moving beyond technocratic approaches to adaptation and emergency response, emphasized by prominent climate-health commentators (Watts et al., 2015).

4.2. The costs of becoming visible

Assuming that improved quantification of CHR leads to their reduction is implicitly positivist and from a Foucauldian perspective,

somewhat naive. If we consider environmental risks as *produced*, *predictable* and *calculable*, then why do states (or international actors) not do more to 'manipulate the conditions of life' in order to reduce risks across spatial and social gradients? The answer, we contend, is that marginalized people are dispensable citizens (Jalais, 2014), rather than because of technocratic blindspots in state legibility. Hence, improvements in monitoring and research capacity may not affect the political will to reduce certain kinds of CHR. Moreover, state legibility carries risks; there are trade-offs in being (in)visible and these are shaped by degrees of privilege. For example, a small-scale study in Canada found that an indigenous person's *visibility* (i.e. appearing 'different') simultaneously produced them as *invisible* to healthcare providers (e.g. being ignored), with resultant lack of respect impairing their treatment and care quality (Hole et al., 2015). This duality perpetuates experiences of oppression and social exclusion. Nonetheless, the authors re-frame visibility as normatively positive, equating being seen, heard and respected as an aboriginal person with being "*treated as a "human being" in the patient-caregiver relationship*" (p.1666).

However, we return here to Agamben's (1998) exploration of contexts where social groups are subject to the law and its discipline, but deprived of entitlements and rights. Related cases in the Americas compel our support for Jones et al. (2016), who advocate respecting the invisibility of people who use hiding as a strategy. Perhaps the clearest example is undocumented immigrants; for whom being visible to the state could trigger imprisonment, family separation or deportation. Hence, after 2013 floods in Colorado, migrants avoided emergency responders due to fear of deportation (Romero-Lankao and Norton, 2018). Moreover, many Latino owner-occupiers of mobile homes paid ground-rent and were therefore denied governmental financial recovery support because this entitlement was restricted to homeowners with land tenure. Even when a state's position is broadly agnostic, exemplified by Venezuelan migrants in Brazil, organized violence reinforces the point that invisibility can be protective. Likewise, residents in slum settlements may be compelled to choose invisibility due to risks of forced removal. Scott (1998, p. 54) cautions that being mapped and measured can expose households to eviction due to perceived illegality or environmental risks. He argues that illegibility of marginalized urban neighborhoods or rural settlements in marshes and forests has, historically, provided "*a vital margin of political safety from control by outside elites*".

The first author's research in the Brazilian Amazon (see: <http://wp.lancs.ac.uk/rede-cidada-am/>) shows how climatic shocks peel away this insulation; residents of Turrufão - a marginalized riverine neighbourhood of stilted households in the remote town of Ipixuna, Amazonas, were strongly affected by flooding in 2017 but were keen to remain, repairing homes and maintaining water-related livelihoods such as fishing. However, the *Defesa Civil* used GPS-mapping and spray-paint numbering to make legible, and involuntarily register affected households for relocation to distant upland peri-urban neighbourhoods. From semi-structured interviews, informal conversations and a multi-stakeholder workshop held in May 2017, it became clear that the state's actions were oppressive for Turrufão's residents – most of whom had previously migrated from rural communities. A future far from the river would compromise their social networks, way of life and sustenance practices. Moreover, they distrusted the municipal government's commitment to providing quality housing and basic services, and their own capacity to demand action in response to any shortcomings. The *Defesa Civil's* narrow focus on flood-avoidance, and culturally-racist refusal to listen to concerns of residents resonate with Scott's assertion that "*almost all strictly functional single-purpose institutions have some of the qualities of sensory-deprivation tanks*" and can diminish the skills, initiative, and morale of their intended beneficiaries (Scott, 1998, p.349).

Mapping in Ipixuna recollects Elden's (2007) concern that visualizing or mapping territory makes space *governable*. Amazonian examples demonstrate that whilst there are health benefits such as new

health posts and rights accruing from territory-demarkation, there are also risks. For instance, Munduruku Indians' outcry at the desecration of their 'heaven' due to a new hydro-electric dam was delegitimized by an embresarial-ministerial powerbloc that refused to recognize the claim because the sacred location fell outside of legalistic agreements on the limits of Munduruku's territory (Branford et al., 2017). Furthermore, as illustrated in New Orleans post-Katrina, state-led or sanctioned 'management' of climate-related risks can become economic opportunities through which the vulnerable can, to quote Nally (2008), be "improved out of existence". Consequently, a community's legibility strengthens the state's capacity for large-scale social engineering, which is particularly dangerous when civil society is weak - further degrading political autonomy (Scott, 1998). So, are the greatest risks from climate change or the indirect consequences of related social transformation which disfavour the marginalized?

The costs of visibility or scientific evidence of climatic variability are diverse. For instance, there is stigma and discrimination associated with neglected diseases (Auger, 2012) and mental health conditions (Henderson et al., 2014). Research from Brazil's North-East also shows how climate monitoring/forecasting information can disadvantage the most vulnerable through 'technocratic insulation'. Lemos and Dilling (2007) found that household resources, related to language, literacy and technology/wealth and unequal relations with gatekeepers underpinned disparities in access to information, which intensified power imbalances. Informational disparities help explain why certain actors are sometimes able to benefit from climatic shocks such as drought. In Guatemala's high mountains, powerful actors substitute a paucity of reliable public weather and climate data with privately-owned instrumentation or privately-sourced data products (Pons et al., 2017).

4.3. Safeguarding invisibility

Evidence suggests that it is hard to render visible CHR without compromising the illegibility of certain communities, which is "a hindrance to any effective intervention by the state, whether the purpose of that intervention is plunder or public welfare" (Scott, 1998, p.76). Scott also highlights the unavoidable errors in state facts - upon which, administrators and courts rely. Hence an error - e.g. households being incorrectly assigned as high flood-risk - "can have far more power - and for far longer - than an unreported truth" (p.83). Thus, municipal designation of houses in Ipixuna as uninhabitable due to flood-risks represents the 'authoritative tune' to which a population 'must dance' (Scott, 1998, p.83). This is a case where hiding can be an effective strategy of the disempowered. In this sense, there can be secret complicity between marginalized communities who feel compelled to remain unseen and states that have other priorities. Nonetheless, those hiding could still benefit from policy interventions that increase healthcare access and provide emergency assistance during climatic extremes.

The promise and perils of increasing visibility poses a wicked problem (Nixon, 2011, p.15). Lund and Eilenberg (2017) favour visibility: "For many people, the grim reality is ... that there is only one thing worse than being seen by political authority, and that is not being seen" (p.6) due to the dependence on visibility for gaining political recognition, overcoming exclusion and achieving rights. This resonates with Agamben's view that we must *insist* on our juridical rights. Hence, long-term progress can be sacrificed because invisibility can mean "either 'staying at the sidelines' of public space and engagement" in an "act of subtle political resistance" or can also "be framed as a short-sighted, instrumental tactic to ensure survival" (p.52). But are there more nuanced options than the calculated practices of government such as mapping neighborhoods, registering migrants? How can we address the underlying causes of invisibility whilst accepting the right of those under pressure to wear a protective 'cloak of invisibility' (Hole et al., 2015). We envisage two parallel strategies.

4.4. Helping the marginalized to reach out for power

In moving forward, we recall two key characteristics of Foucault's notion of governmentality. The first is the will of the state to take responsibility for the health of populations. Climate change may be low on Latin American political agendas, yet most states see public health as a moral and practical imperative. Second, is the understanding that modern power is dispersed across a field of strategic operations, hence there is always scope for counter-conduct, or counter-claims making. To govern, as Li puts it: "means to act on the actions of subjects who retain the capacity to act otherwise" (2007, p.17). These points remind us that governmentality is always open to resistant possibilities beyond evasion and subterfuge.

We take seriously Barnett and Scott's (2007) suggestion that the reaching out of democratic states to observe and influence their populace opens up possibilities of an inverse movement - that of citizens reaching back and making claims of the state. Legibility is not unidirectional: in visualizing its subjects the state also makes itself visible and proximate. Barnett and Scott contend that relationships between states and citizens are, at least potentially, "structured around a set of interactions in which each attempts to make enforceable demands on the other" (2007, p. 294). This is not a luxury reserved for historically well-established and privileged polities. Using post-apartheid South Africa as their example, they show how legacies of conflict, inequality and disempowerment can provide leverage for two-way claims making.

A way to overcome marginalization - and invisibility - is to support the capacity of the marginalized to resist the violations of their fundamental rights (Porto et al., 2017). This facilitates social and political recognition, making the experiences of the powerless relevant and visible and could be achieved by fostering social accountability and empowerment - akin to building up civil society. The same processes are identified as central to improving healthcare access and quality in low and middle income countries (Kruk et al., 2018). Marmot et al. (2008) also argued that political empowerment (inclusion and voice) is key to improving social determinants of health. Furthermore, principles of empowerment and participation are enshrined in WHO's Bangkok Charter (2005) and central to achieving health promotion's emancipatory goal. These principles underpin long-term strategies of advocacy, mediation and enabling, agreed under the 1986 Ottawa Charter (Potvin and Jones, 2011).

Building the capacity to resist speaks to WHO's work on social mobilization and good governance (<https://www.who.int/healthpromotion/fact-sheet/en/>), and Barnett and Scott's (2007) notion of 'reaching for power': attempting a strategic reversal of legibility through which the governed are able to visualize and speak back to governing institutions. The extensive networks that government agencies and nongovernmental organizations have extended into developing regions provide pathways through which the subjects of governance are able to make their own claims, often as concrete demands "around the provision of certain sorts of stuff— water, basic consumer goods and services, access to health care" (Barnett, 2017, p. 137). Hence, increasing citizens' ability to draw states and non-state actors into their reach through soft power (shame, blame, responsibility) and juridical power (accountability, liability, entitlement) is fundamental to developing equitable state-citizen relationships of mutually-enforceable rights and obligations. This resonates with Lund and Eilenberg's (2017, p.9) assertion that consolidating rights means wrestling them from power - and social accountability and empowerment will also support institutions that "emerge to reproduce and protect entrenched rights". Indeed, there are sophisticated strategies of (in)visibility in which, "while being careful to avoid certain governing agencies, people simultaneously exert great effort, imagination and flexibility in order to be seen by others" (p.11). Key is their observation that "strategies of visibility and obscurity depend on the context, on the authorities' ambitions and resources, and on people's available options" (p.11).

At first impression, under-resourced postcolonial states grappling

with health risks and escalating demands of climate change offers an unpromising context for the disempowered to assert their own demands. But Chatterjee reminds us that it is precisely such fluid, unsettled situations that make it possible for rules and procedures to ‘bent or stretched’ (2004, p.60). In this regard what Ghosh (2018) refers to as ‘climate derangement’ – with its implication of a disruption in the way that realities are sensed and ordered – can also be viewed as a juncture in which the content and contours of the political are unusually susceptible to renegotiation.

4.5. Changing research agendas and structures

Watts et al. (2015) argue there is urgent need for more investment in climate change and public health research, monitoring, and surveillance in the Global South. However, investments should be sensitive to the risks of visibility and power imbalances, and promote trans-disciplinary research that pursues locally relevant agendas, recognizes cultural values (Turner et al., 2008), and co-produces knowledge.

We suggest that climate-health research would benefit from additional tools such as municipal measures of healthcare access and quality, especially useful in decentralized contexts. Building local monitoring capacity empowers those experiencing climate change, exemplified by weather-monitoring innovations in Guatemala (Pons et al., 2017), and co-development of locally relevant health indicators with indigenous communities on the Salish Sea coast (US/Canada) (Donatuto et al., 2014).

The knowledge gaps we identify point to the need for ambitious new research agendas around mental health and climate change in the Global South. Priorities include establishing reliable baseline mental disorder prevalence for vulnerable social groups (e.g. riverine Amazonians) (Bonadiman et al., 2017), examining mental and physical health impacts of river flooding, and assessing potential lifelong consequences of exposure to extreme climatic events during pregnancy or early childhood (e.g. Skoufias and Vinha, 2012). It is also crucial to examine how mental and physical CHR are shaped by social and political factors (e.g. political decisions to disrespect undocumented migrants’ right to health). An intersectionality approach would be complimentary here, given its utility in “making visible the fluid and interconnected structures of power that create ... health inequities” (Larson et al., 2016, p.964). Reducing invisibility whilst protecting the marginalized demands a central role for social sciences, including qualitative methodologies and long-term commitments to research with, rather than on, communities (Nixon, 2011). Physical science priorities include filling geographic gaps in meteorological and hydrological monitoring and developing multi-hazard early warning systems with universal coverage (UNEP, 2012). However, information must be locally relevant, transparent and accessible to citizens, thereby promoting social accountability and empowerment.

Structural changes are necessary to reducing inequities and poverty and to achieve more equitable development. This is concordant with Marmot et al’s (2008) argument that tackling inequities of power and resources, which are macro-scale determinants of health, requires health equity in all policies, systems and programmes; fair financing and market responsibility; gender equity; political empowerment and good global governance. Improved living standards, combined with greater public health investment, would provide benefits well beyond climate change preparedness. At national scales, priorities include resolving inter-ministry conflicts and improved communication across government and external agencies (Watts et al., 2015).

5. Conclusions

Our paper lays bare the systematic biases and blindspots in current understanding of the health-risks posed by climatic change, situating these as the outcomes of intersecting forms of marginalization. Marginalization renders invisible key determinants of health including

hazard exposure, disease-risk and burden, harm and ‘slow’ violence, planning and adaptation deficiencies. Hence, not only are disadvantaged groups more vulnerable to climate change, but their health risks are less visible to scientists and policy-makers. This article contends that social and spatial context not only determines health but shapes the visibility of health-risks from global environmental change. Notably, evidence relating social marginalization to invisibility and CHR was stronger than other forms, such as spatial marginalization or mental health. We identified key research gaps and argue for an intersectionality approach in climate-health research.

Attentive to the politics of the governed, our thesis is that there are deep, context-dependent tensions around whether benefits of rendering the marginalized’s climate-related health-risks more visible to the state (and researchers) outweigh costs. One needs to be seen in order to be politically counted and receive rights. Evidence shows that governments can be relatively neglectful of the health and well-being of some social groups, but at the same time liable to make impositions on those in its gaze. In this sense, we interpret blind-spots as forms of strategic neglect rather than just ‘knowledge-gaps’. Based on Foucault and Scott’s thinking around governmentality, and diverse examples from Latin America, we show how using state-led technical expertise and quantitative data to make health-risks more visible also poses threats to those at society’s margins. Nonetheless, we advocate that vulnerability to climate change cannot be ignored, forcing us to move beyond Scott’s view of the state as primarily an agent of coercion and domination. Instead, we engage with Barnett and Scott’s (2007) theorizing of citizenship and propose a strategy to enable the marginalized to reach out for greater power, both soft and juridical, and in-so-doing renegotiate the conditions of their own legibility and begin claims-making for the concrete benefits that can attend visibility.

Overall, the invisibility of climate-related disease is unjust and equates to structural violence and is (re)produced by power imbalances, linked to uneven development, poverty, and globally-biased health agendas that determine funding and the political gaze. Borrowing Lund and Eilenberg’s (2017, p.4) terminology, we conceptualize climate change and related policy debates (right down to municipal politics in remote Amazonian towns) as a “rupture” or “open moment” when both risks and opportunities multiply, such as for establishing new contracts of social recognition. Key positive advances would be fostering empowerment and social accountability -, including within health systems - as means of reducing the risks of visibility and demanding socially just governmental action on climate change. However, the ‘turbulence’ of climate change unleashes and exacerbates political and economic turmoil, including migrations. Consequently, strategic state neglect, and tactical hiding by marginalized peoples may constitute part of the greater climate change ‘derangement’ (Ghosh, 2018).

Declaration of interest

None.

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