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Blinders of extreme heat adaptation: uneven urban development and the reproduction of vulnerabilities

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ABSTRACT

Despite its deadly nature, extreme heat has received fragmented and scattered responses in cities, often overlooking the crucial social and equity components. Dominant adaptation approaches have paid little attention to chronic socio-economic vulnerabilities to heat stress, resulting in a lack of strategic planning to address them. Building upon critical urban studies and adaptation scholarship, this article examines how the dynamics of urban climate adaptation in the Global North have sidestepped the root causes of heat vulnerability and their (re)production in past, present and future practices of uneven urban development and planning under austerity. We investigate this empirically in attending to the framing of adaptation, the instruments used and the biases they introduce in Montreal (Canada), as well the perception from planners and community groups regarding their agency in responding to extreme heat. We contribute to the literature in analysing how the urban governance of adaptation in urban planning tends to silence the social production of vulnerabilities by three intersecting processes: the biases of instruments used, the unacknowledged legacies of uneven urban development, and the lacking recognition and support for community organisations caring practices.

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Introduction

While cities are particularly touched by heat waves which disproportionately affect socially marginalised groups and older residents, the responses to extreme heat remain limited and fragmented (Chakraborty et al. 2019; Keith, Meerow, and Wagner 2019; Turner et al. 2022). Yet, extreme heat stands as one – if not the – deadliest climate hazard, with steep increases anticipated in the future and unequal exposure and vulnerabilities among populations, hindering local and global climate justice and equity goals (Wilson 2020; Zhang 2023).

This article focuses on climate adaptation to extreme heat in cities of the Global North. We begin by reviewing the dominant approaches to heat adaptation, as outlined in recent reviews of adaptation plans: the greening measures aimed at reducing the heat island effect and emergency management strategies. These two dominant approaches leave an immense gap uncared for in formal practices of adaptation: the chronic and unequal social factors of vulnerability to extreme heat. Drawing from critical adaptation and urban studies literature, we explore the governance processes that elucidate why little attention is given to the root causes of heat vulnerability in cities.

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Utilising Montreal as a case study and leveraging a recent living lab on adaptation in urban redevelopment, we delve into the intricacies of the governance processes and planning instruments that contribute to the (re)production of heat vulnerability in urban areas. We also examine the informal supportive and caring practices that address vulnerability but often remain unacknowledged in formal climate adaptation strategies. A key issue that hinders progress, and on which we focus here, is the lack of recognition of the legacies of uneven development and austerity, which are crucial aspects to consider in order to enhance the scope of just climate adaptation (Castán Broto 2021).

We argue for a deeper understanding of the politics of adaptation within the everyday instruments of urban planning and the grounded experience of community action. Our objective extends beyond the Montreal empirical case or the strict analysis of adaptation plans, to identify broader processes of urban governance that impede effective action against the continued production of vulnerabilities to extreme heat. We also emphasise the significance of grassroots and community work that identify these drivers of vulnerabilities but face structural constraints in their work to reduce them.

Adaptation to extreme heat in cities of the Global North

Reviews of local adaptation plans have identified clear biases and shortcomings of current dominating approaches. In the last few years, attention to extreme heat seems to have increased; yet, authors agree that the vast majority of cities still “fail to frame the problem of heat with any level of specificity”, and that “plans do not include key framings we would expect to find in robust plans to protect people from heat” (Turner et al. 2022, 7; Gabbe et al. 2021), with dominant approaches being insufficient and disjointed. After their analysis of 175 municipal plans in the US, Turner et al. (2022) indeed identified two distinct and separate regulatory regimes: one focused on the heat island effect and the other on emergency responses. These two dominant trends were also found by Turek-Hankins et al. (2021) for the Europe and North American sample of their global data set of adopted measures to face extreme heat, and confirm trends noted in other reviews discussed below. In addition to these two dominant trends, some articles also discuss the use of heat vulnerability assessments to guide heat adaptation, but mostly to note they are not used or available in a majority of cases.¹ Other potential measures could include bylaws or programs for behavioural change during extreme heat (limiting work for example), climate cooling centres or resilience hubs, buddy programs for support in the neighbourhood, housing policies and programs to increase the access to social, health and community services (LaLone 2012; Bolitho and Miller 2017; Amorim-Maia et al. 2024; Turner et al. 2022). If this article focuses on the social consequences of extreme heat in cities, and their prevention, there are numerous ecological consequences as well, which in turn affect human and non-human life alike. Heat waves increase water temperature and affect aquatic life, increase the occurrence of wildfire, affecting life in forests and peat mosses, and disturb species distribution and migration (IPCC 2022).

In North American cities, the first dominant regime of heat adaptation focuses on reducing the urban heat-island effect (UHI). Indeed, in urban planning and design, extreme heat is primarily discussed in relation to mapping the heat island effect and devising greening responses accordingly (Keith, Meerow, and Wagner 2019). In this regime, the emphasis is placed on trees and physical interventions implemented outside of residential dwellings, without social programs like cooling centres or buddy heat programs, failing to address the experiences of heat stress within homes (Turner et al. 2022). Greening interventions have many positive health and indirect socio-economic benefits for the population; they can be inclusive and allow for community management and empowerment (Bikomeye et al. 2021; Burbidge et al. 2022). Greening also has ecological cobenefits, such as improving urban biodiversity and reducing air pollution, although it has costs in terms of water consumption. However, greening initiatives have in certain instances been favouring already affluent and white parts of cities while ignoring socially deprived neighbourhoods, or

targeting the latter as part of development strategies and hence contributing to green gentrification (Anguelovski et al. 2022).

The other dominant adaptation to heat in cities is the emergency management approach of “extreme heat events” (EHE), which focuses on public health emergency protocols to reduce mortality during heat waves, and information campaigns. This approach is also found in several parts of the world beyond the US, and limits have also been discussed. Zaidi and Pelling (2015) considered that heatwaves in cities of Great Britain were considered emergency events to be treated medically by public health agencies, thereby restricting the community’s response to a limited network of actors and a certain temporality. Bolitho and Miller (2017) also concluded that the dominant attention to emergency response and alert systems in Melbourne limited the ability to work on reducing factors increasing chronic heat stress in communities. Zaidi and Pelling (2015), Zografos et al. (2016) and Bolitho and Miller (2017) all speak of collaborations to strengthen with organisations involved with newly arrived immigrant populations, the elderly, disabled persons, the sick or socially isolated, with “knowledge of the community and their communication and support requirements, as well as people’s coping mechanisms and support networks (691)”. Strong relations between such social support, urban planning and mobility are also found lacking.

Clearly, there is a need to bridge between but also expand these two approaches for a more effective governance of adaptation to extreme heat in cities. Siloed governance is identified as a key issue, in parallel to a lack of legislative frameworks (in building codes, housing and municipal regulations). In this context, it seems indeed that “extreme heat has no problem owner” in most cities today (Keith, Meerow, and Wagner 2019). Its governance is fragmented, lacking in collaborative work and leadership (Bolitho and Miller 2017; Keith, Meerow, and Wagner 2019; Turner et al. 2022; WHO 2021).

Heat adaptation also appears to be constrained, in both the emergency management and UHI framings, by a focus of climate adaptation investments on the resilience of the built environment to hazards, in particular flooding hazards. Recent studies have highlighted how asset-based risk analysis and power imbalances in the expertise around green infrastructure have in many cities in US and Canada favoured a focus on stormwater management priority (adapting the built environment to flash floods from intense rain events) with less attention to health vulnerabilities to heat, and to equity and justice, in the distribution and type of greening in the city (Finewood et al. 2019; Meerow 2020; Van Neste et al. 2024). This “bias in hazards” is also discussed by Barnes and Dow (2022) who speak of mutually reinforcing processes – organisational, coalition-building, expertise and channelling of investment – that reproduce a focus on water hazards in situations of multiple compounded hazards of both heat and water. In the US, Hamstead (2023) explains such phenomenon by the integration of heat adaptation measures within existing environmental management regimes. These regimes were initially established to govern water management and safeguard property, to ensure public safety. This brings a focus on reducing and absorbing risks for the built environment and real estate in hazardous flood-prone areas.

Together, these three trends seem to reinforce a missing focus of adaptation: equity and the social drivers of vulnerability to extreme heat. This is despite the fact that climate justice seems to be more and more put on the agenda of cities and at the core of the challenges of climate urbanism (Bulkeley 2021). But the focus on greening, emergency responses and protecting the built environment against water hazards falls short of working on chronic social factors of vulnerability, in relation to heat and uneven urban development in particular (Hamstead 2023; Turner et al. 2022). The lacking emphasis on social drivers of vulnerability is also visible for climate action plans generally in the US and Canada, in particular for the majority of plans that focus on greening, with still insufficient attention to gentrification and intersectional precarity (Angelo et al. 2022; Shokry et al. 2022; Susarla 2023; Lesnikowski, forthcoming). Some North American cities do however, in their *resilience* plans, speak to social equity (if often vaguely), more equitable access to services and addressing racial inequality in the city (Meerow et al. 2019). In heat adaptation planning however, social drivers of vulnerability, precarity in housing or unequal access to services are little included, if not absent in measures

(Hamstead 2023; Turner et al. 2022), except in some cases to speak of cooling centres and the development of vulnerability assessments. Only one third of US plans analysed by Turner et al. (2022) present heat adaptation as an issue of equity.

Some cities do adopt measures of capacity building, with the objective of increasing adaptive capacity in marginalised communities. Yet this is the type of approach least detailed and described in documents, marginally present in North America (Turner et al. 2022; Turek-Hankins et al. 2021; Uli-barri et al. 2022), although grassroots initiatives of course exist, as we will see below (Ranganathan and Bratman 2021; Amorim-Maia et al. 2024). For Guardaro et al. (2020, 2022), local government approaches dedicated to improving social capital and adaptive capacity are often too vague and generic, not specific enough to attend to the particular challenges of extreme heat.

This low attention to social drivers of heat vulnerability in climate plans contrast with the large development of indicators and geospatial mapping of vulnerability to extreme heat and the thermal landscape of inequity, including dimensions that relate to housing conditions and poverty (Mitchell and Chakraborty 2015). Recent studies and surveys in the US and the UK suggest however that this work of vulnerability mapping is often not available to practitioners and is scantily impacting priorities for adaptation in policies and decision-making (Meerow and Keith 2022; Wolf, Chuang, and McGregor 2015).

Clearly, the dominant framings of heat adaptation affect the type of interventions, strategies, resources and actors included. To understand these dynamics and the unfolding of these dominant framings of heat adaptation in cities, we need to go beyond the content of plans. In the next section, we discuss three processes which may be key in this sidelining of social drivers of vulnerability.

Sidelining the socially produced drivers of heat vulnerability

We build on urban and critical adaptation scholarship to conceptualise three processes that help understand why socially produced drivers of vulnerability remain at the margin of climate adaptation, obscured or unquestioned. This proposal aligns with the call from Zoe Hamstead (2023) to critically assess dominant heat adaptation measures in their depoliticised, ahistorical and disembodied dimensions. The concrete processes we wish to point attention to are the following: (1) the policy regime and government instruments supporting the dominant political framings of adaptation, (2) the non-recognition of the legacies of uneven urban development and (3) the invisible embodied experience and caring practices around heat insecurity. The analytical focus on these three processes then allows us to interrogate the concrete governance frameworks, instruments and practices that unfold in the Montreal urban climate adaptation planning.

Instruments and the assumptions they carry

The first process that can contribute to sidelining the social drivers of vulnerability is the policy regimes and government instruments supporting certain framings of adaptation (Hamstead 2023; Henstra 2016; Lascoumes and Le Galès 2005). The dominant framings of heat adaptation we presented above are institutionally designed and reflect power and resource asymmetries between different actors and sections of the State, with implications on « what is included on the agenda, and what is silenced » (O'Brien et al. 2007, 76; Zaidi and Pelling 2015). Climate adaptation and resilience initiatives have a tendency to be presented as an apolitical endeavour, with no political choices involved, with a somewhat invisible politics of determining priorities, what and whom is more worthy of assistance (Eriksen, Nightingale, and Eakin 2015; Mikulewicz 2018; Nightingale 2017). This politics is not always obvious, for ways of framing the problem and solutions are normalised in institutional mandates, codes and instruments from key actors with resources and powers to intervene. The details of government instruments used and their power in determining the boundaries of climate adaptation can have important stakes. Henstra (2016) has detailed four key governance resources for adaptation through which we can distinguish different sets of government

instruments: those focused on information (ex: mapping of vulnerability), on the exercise of authority (ex: regulations and bylaws), on the use of treasure (investments and economic tools), and of government organisation (delivery of programs and services, use of state physical and human capital). As Henstra outlines it, government instruments are not neutral; each type carries its own set of assumptions, can be more or less resource intensive and more or less precise in reaching the most in need.

This mainstreaming of adaptation in programs and instruments is influenced by wider trends and ideologies, within which the framings of heat adaptation are developed and understood. In urban studies, Long and Rice (2019) have noted a dominant mode of climate urbanism which selectively prioritises win-win interventions of adaptation that benefit to real estate development and urban growth, threatening to increase inequalities in cities. Equity is seldom operationalised in concrete measures (Angelo et al. 2022; Susarla 2023; Turek-Hankins et al. 2021; Turner et al. 2022). The neoliberal vision of climate urbanism also encourages an individualisation of responsibility to adapt and face climate hazards at home, while the government focuses on information (Bee, Rice, and Trauger 2015; Hamstead 2023). As we have outlined above, heat as a chronic social stress is not much visible in current adaptation plans and practices. When it is, especially in localities where heat stress is stronger, scholars argue that it is most often treated “as a matter of personal protection that can be remedied via informational campaigns” (Hamstead 2023, 161; also in Mees, Driessen, and Runhaar 2015).

The mainstreaming of climate adaptation still tends to emphasise climate change as an external threat to society to prepare for, reproducing a dualism between climate (as a separate natural force) and human societies struggling to adapt. This constrains our ability to consider the dynamics of interrelated social and environmental change (Eriksen, Nightingale, and Eakin 2015; Nightingale et al. 2020). This separation contrasts with the lasting contribution of risks and social disaster scholars emphasising the contextual and socially produced character of vulnerabilities to climate hazards. Wisner et al. (2003) had conceptualised this production of vulnerability at different levels and into a chain of consequences: from the root causes of vulnerabilities (structural forms of dominations and unequal social relations materialising into limited access to power and resources) that contribute to dynamic pressures of society producing for certain populations unsafe conditions and lacking resources in daily life; these conditions of living and access are then what transform a meteorological event into a social disaster, with the direct negative impacts affecting conditions of living on the long term, producing chronic stress. From this perspective, equalising access to resources and conditions of living are key leverage points for just adaptation (Ribot 2010).

Unacknowledged legacies of uneven development

This dominant separation of climate hazards as “natural” external threats from the societies in need to adapt also connects with the literature on the production of space under capitalism. Urbanisation unfolds through uneven development that materially structures unjust power relations and socioecological cleavages over the long term (Castán Broto 2021; Goodling, Green, and McClintock 2015; Lampis et al. 2022; Smith 2010). As Goodling, Green, and McClintock 2015 sum it up, inequities in the built environment “are shaped by cycles of capital accumulation and devaluation and by the social processes (including policymaking and planning) that mediate them”(p.509). Uneven urban development produces inequalities that sediment over time in urban structures that become taken for granted and perceived as inevitable, especially in relation to heat (Burbidge et al. 2022; Guardaro et al. 2020).

This is thus the second process we emphasise, at the core of this sidelining of the socially produced drivers of vulnerabilities: their long history and embeddedness in past legacies of uneven urban development. History can help show the sociopolitical construction of the city, including how stigmatisation, segregation and colonisation sediment in the material fabric of the city and affect future development pathways, resulting in unequal access to services, decay of infrastructure, and vulnerabilities to compound crises (Rumbach 2017; Westman et al. 2022). Recent work in

mapping thermal inequities shows the impact of unfair housing policies and systematic racism (e.g. redlining) on the current unequal heat exposure and lower adaptive capacity (Gabbe and Pierce 2020; Wilson 2020). Dynamics of urban neglect also come in to play. The classic ethnographic study by Klinenberg (2015) documented how the chronological succession of white flight, deindustrialisation and public disinvestment caused commercial devitalisation and degradation of social life in several Chicago neighbourhoods. These processes resulted in the depletion of what he conceptualised as “social infrastructure” which explains why the death toll in abandoned and predominantly Black neighbourhoods during the 1995 heatwave was four times higher than in Latino neighbourhoods with more social infrastructure.

Invisibilization of caring practices

The third process which we think is sidelining the drivers of vulnerability in climate adaptation is the invisibilization of certain experiences, knowledge and practices. We speak in particular of the differentiated embodied experiences of heat and the knowledge in the adaptation praxis of mutual aid, caring and preserving for social infrastructures threatened by unequal urban development (Hamstead 2023; Williams 2017; Lopes et al. 2018; Klinenberg 2015). This relates to the epistemologies of extreme heat, that have represented the problem of heat as an increase in meteorological degree or as a geospatial localisation expressing relative vulnerability (Hamstead 2023; Oppermann et al. 2018), contrasting with its differentiated embodied experience whether one suffers from racism, house violence, addictions or precarious housing conditions, the work and care responsibilities they carry, whether there is air conditioning in the house and whether it is at ground, top floor, sanitary and ventilated, if one has, knows and trust neighbours and public facilities around, etc. (Stern 2023). Feminist critiques of climate change governance have discussed how climate interventions tend to have universalising narratives that detach climate change from everyday spaces and “downplay experiential, embodied, and non-scientific forms of knowledge” (Bee, Rice, and Trauger 2015, 10). This can have the effect of obscuring different social and spatial experiences, ignoring the effects and intersection of gender, class, race, and other forms of oppression (Hamstead 2023). Indeed, while adaptation planning tends to focus on future external threats, grassroots organisations imagine resilience quite differently, focusing on the “intersectional drivers of precarity” (Ranganathan and Bratman 2021). Along with several authors attentive to urban environmental injustice, they advocate for greater consideration for the intersectional and cumulative experience of climate hazards with other processes of oppression and marginalisation in society.

The everyday diverse experiences and practices of adapting to heat are not much visible in adaptation planning (Guardaro et al. 2022; Hamstead 2023; Oppermann et al. 2018). For Guardaro, adaptive capacity tends to be defined in general terms, rather than in relation to embodied heat experience and the individual and collective cultural ways of living with it (Guardaro et al. 2022). In their heat planning workshops, Guardaro et al. relied on people’s narratives to make tangible their experience of extreme heat and the community organising and care around it. This knowledge from caring and mutual aid is rarely visible and recognised in adaptation planning. Yet, community-based adaptation has been assessed as important for extreme heat adaptation because of its capacity to reduce social isolation (Rohat et al. 2021), especially considering the ability to reach residents most vulnerable to heatwaves, due to grassroots expertise and local knowledge (Burchell et al. 2017). Neoliberal restructurings of service provision have contributed to making care a pressing concern while simultaneously marginalising it from view (Lawson 2007).

Studying climate adaptation in the making in Montreal: context and methods

We study these processes in a city with a certain leadership on climate issues, Montreal: Tiohtià:ke. Climate action has come at the forefront of the City’s political agenda since the election of Mayor Valérie Plante in 2017 and a new Office for Ecological Transition and Resilience. But policies had

been developed before that, with the first mitigation plan in 2013 and the first adaptation plan in 2015 (City of Montreal 2015a).

Tiohtià:ke/Montreal, is the second-largest city in Canada, built on unceded indigenous territories. The agglomeration is home to 1,9 million people, with a median income of 29 1981\$, 17% of the population low-income and 31% of the population belonging to a visible minority (City of Montreal 2018). Montreal has a poorer population than the other major Canadian cities, with lower costs of living and basic needs, but has known a stark increase in rent costs, and a lack of affordable housing since the pandemics (StatCan2024). Montreal is also characterised by an institutionalised network of community organisations which shows a potential for community-based heat adaptation. In this context and methods section, we introduce the content of the most recent climate plans and the particular research setting through which we studied the actual framing and operationalising of climate adaptation.

The City of Montreal is concerned with the following climate hazards, which are identified in its climate adaptation plans: (1) more abundant precipitations, particularly an increase in short and intense rainstorms causing flash floods in the city, in addition to (2) floods from rivers overflow², (3) an increase in average temperature (with impacts on biodiversity and pathogens), (4) an increase in extreme heat days, from 11 days a year in average in the 1980–2010 period to 30–40 in 2050 and 35–55 in 2070 (Ouranos 2023), (5) an increase in destructive storms, tornados but also icy storms disrupting electricity access and (6) an increase in periods of droughts (Ouranos 2023; City of Montreal 2017, 2020). In the first climate adaptation plan (2015, updated 2017), the City speaks to the predicted impacts this will have on the population, on biodiversity and on municipal operations.

To contribute to the Climate plan's implementation in urban planning practices, professionals in the City's Ecological Transition and Resilience Bureau mobilised to have funding for a research-supported living lab. Urban living labs are spaces for creative codesign, testing and learning by doing, outside rigid bureaucratic spaces to facilitate innovation (Loorbach, Frantzeskaki, and Avelino 2017;

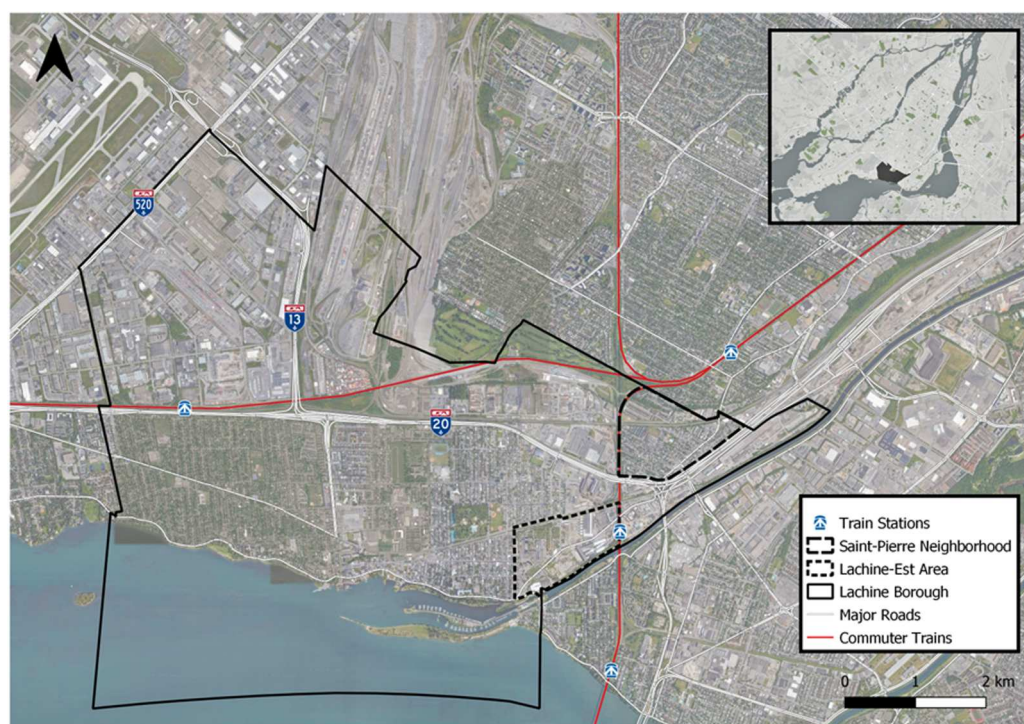


Figure 1. Map of the Lachine borough and Lachine-Est area, Montreal, Canada. Made by Émilie Houde-Tremblay.

Marvin et al. 2018). To reflect the complexity of urban planning, the Lachine-Est site – a 125-acre brownfield site coveted for housing and commercial development – was chosen by practitioners as the starting point of the living lab (Figure 1). Such urban megaprojects are often expected to attract investment, mobilise expertise, and provide opportunities to develop innovations and work on new standards (Majoor 2018). Yet, the redevelopment of Lachine did provide an ambiguous starting point for innovation in climate adaptation, with the danger of focusing on win-win solutions for adaptation and urban development which could be in contradiction with prioritising the reduction of social vulnerabilities (Long and Rice 2019; Van Neste et al. 2024). In this planning process for the redevelopment of the Lachine-Est ecodistrict area, local community groups won a spot at the table in the core governance and coordination committee, normally reserved to city practitioners. We made the hypothesis this could help increase the community and social components of adaptation measures.

Our broader project³ first involved two steps: (1) investigating the governance, power asymmetries and initial framing of climate adaptation in Montreal and the ecodistrict; (2) conducting living lab workshops to challenge and refine our mutual understanding with practitioners. Initially, in step 1, interviews, documentary analysis, and participant observation were employed to evaluate the governance landscape, framing and instruments of adaptation. Subsequently, insights gleaned from these initial assessments informed the design of participatory workshops (step 2). The results from workshops provided complementary insights, confirming a low attention to drivers of heat vulnerability in the planning process. After witnessing this, we added to the living lab a community-based research on extreme heat (Poulin et al. 2021, D'Amours 2023), the third step in the data collection and the basis of this article for two of the three processes discussed.

For the community-based research, we started with residents⁴ and local community groups working in most deprived neighbourhoods around Lachine-Est, with the help of our community partner (10 interviews and one focus group, Poulin et al. 2021), to then extend our study across Montreal (17 interviews, by D'Amours 2023). The objective was to investigate how community groups responded to the challenge of adapting to extreme heat, and how they perceived their role and the resources they mobilised or found wanting. In total, this article is based on 53 interviews with planners, community groups and stakeholders, 4 workshops, 1 focus group, analysis of 102 documents and more than 50 hours of participant observation. Table S1 in the Supplementary Material provides, for each step of data collection, details of the participants or documents, questions asked, and the timing and lengths of each encounter. The table presents 9 data sets (DS) which are referred to, throughout the article, as reference to the empirical data used and triangulated in the analysis.

The literature review outlined earlier, which highlighted three processes diverting attention from the social dimensions of vulnerability to heat, constituted an integral part of our research-action approach. We were informed by the literature to consider their manifestation in Montreal. In the following sections, we consider if and how these processes unfold in concrete planning and governance practices in Montreal. The first process concerns the unpacking of the governance process and planning instruments used in the megaproject. The second process concerns the representations of the area's history, the (non) recognition of the legacies left by uneven urban development and its relation with social vulnerabilities to extreme heat. The third process relates to the low visibility and support given to certain experiences and caring practices.

Climate adaptation practices and the unrecognised production of vulnerability

Content of the Montreal climate plans

Climate adaptation was first part of sustainability plans in Montreal, and became specifically tackled in the 2015 climate adaptation plan. This plan involved a vulnerability assessment and outlined some social factors of vulnerability. Adaptation capacity was indicated to be too difficult to evaluate, however, a topic noted to be for later improvements (City of Montreal 2015a, 2015b, Annexe A).

The following plan, the 2020–2030 climate plan, was adopted rapidly to follow the C40 timeline of municipal leaders and without consultation of social groups and the general public (Madénian and Van Neste 2023). It is less detailed on the diagnostic and does not discuss social drivers of vulnerability, only mentioning poverty and precarity without associated measures, and with no acknowledgement of the repercussions of systemic racism and colonialism. Concerning heat adaptation, the 2020–2030 plan includes three measures. First, to plan 500 000 more trees to reduce the heat island effect, in priority in areas most vulnerable. Second, to develop an information campaign with the Public Health Agency to individuals in the most vulnerable sectors. Third, to improve the mapping of the heat island effect. The chosen measures reflect the dominant approaches accounted for in the literature, in that it privileges urban greening interventions and information campaigns during heat waves. The plan did mention that most vulnerable sectors would be prioritised for these interventions, and that the analysis of vulnerabilities would be improved and reflected in the priority interventions and new urban bylaws. Moreover, the plan introduces a potentially promising element from a social infrastructure standpoint, namely the development of community resilience centres and the promotion of social support among neighbours facing climate hazards.

Aside the climate plan, urban planning and urban development follow their own governance patterns and practices. Hence, we now turn to the analysis of the specific planning process and instruments that were utilised to operationalise climate adaptation in the Lachine-Est redevelopment.

Urban development framing the priority hazards and territory of adaptation

During the planning process, the comprehensive analysis of vulnerabilities to climate hazards was noticeably absent from the diagnostic phase addressing the challenges and resource requirements, as well as from the hypotheses formulated for urban design and service localisation. While urban planners did make use of heat island effect maps and maps indicating areas susceptible to rainfall-induced floods when considering various design options, they encountered difficulties in attending to the social factors that contribute to vulnerability, as will be further discussed below. Importantly, the maps and data pertaining to vulnerabilities associated with climate hazards were not assigned a specific role or moment within the urban planning process. Although they were to some extent utilised throughout the living lab, their use remained confined within the predetermined prioritisation of hazards and territories as dictated by two specific instruments employed by the municipality during the process – namely infrastructural investments and the zoning bylaw.

The first instrument which came to frame adaptation concerns the investments chosen for development: redevelopment needs the securing of sufficient infrastructural investment. The area in question, a former industrial site, needed new water drainage infrastructure to service a dense urban development. Given that planning to redevelop any urban area quickly raises the question of the basic infrastructure and essential redevelopment prerequisites, this is a key step on the political path of generating enough interest and investment for the redevelopment (DS 1,3,5.1; Van Neste et al. 2021, 2024; Majoor 2018). This prerequisite and the associated funding requirements emerged as pivotal elements during the early planning stages, conferring significant authority to the City of Montreal's water department. This authority is further underscored by their comprehensive documentation of Montreal's susceptibility to intense precipitation events (City of Montreal et al. 2011; City of Montreal 2015a, 2015b; Mailhot, Talbot, and Bolduc 2019; Van Neste et al. 2024). Heavy rainfall exacerbates stormwater pollution, leading to overflow into the St. Lawrence River, and heightens the vulnerability of residential and transportation infrastructure to flooding. Given the escalating frequency of heavy rainfall incidents, these concerns are mounting.

As a result of these various factors, the concept of a resilient Lachine-Est neighbourhood evolved to focus on the resilience to extreme rainfall events (DS 3,4,5.3). This focus finds its rationale in the materiality of the site and the existing infrastructure, which lacks the necessary water drainage systems required for denser development. Yet, Lachine-Est is also a former industrial site with extensive mineralised surfaces much affected by the urban heat island effect. This expansive area is slated

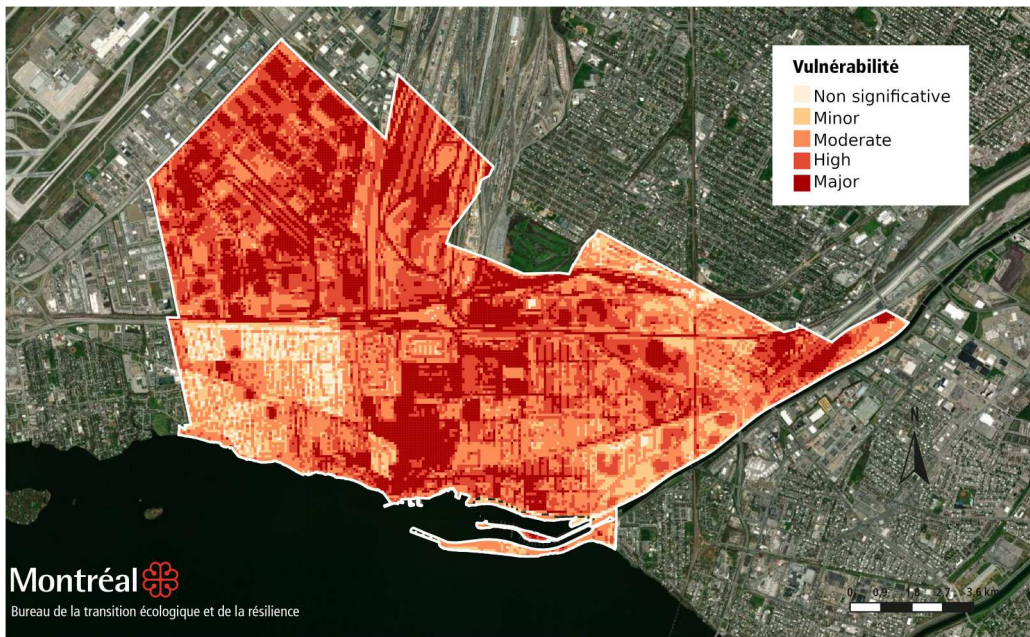


Figure 2. Vulnerability to heat waves in the Lachine Borough. Map from the City of Montreal, with open data available at <https://donnees.montreal.ca/dataset/vulnerabilite-changements-climatiques>.

for phased redevelopment over the coming decades, and there is considerable uncertainty regarding the timing and localisation of public transit infrastructure and nearby services (Rocheffort, in Madénian and Van Neste, *forthcoming*; Rohat et al. 2021). Residents may be forced to endure lengthy walks in sweltering conditions, which is particularly concerning given the rising occurrence of heatwaves in Montreal. Montreal's assessment of social vulnerability to heat waves in the borough show moderate to high vulnerability in Lachine-Est and high to major vulnerability sensibility in directly adjacent neighbourhoods (Figure 2). Yet, extreme heat received little attention (Dagenais and Paquette, in Madénian and Van Neste *forthcoming*; Van Neste et al. 2024). Water management is undoubtedly a priority for the local administration, which faces lawsuits from owners of properties damaged by flooding (this was explicitly cited in meetings (DS 3,5, workshop 3)). On the other hand, extreme heat, which has major health consequences, is not subject to such accountability by the municipal departments participating in the early phases of urban planning (DS 3,4).

This prioritising of existing vulnerability to increased rainwater over social vulnerability to heat waves was visible in the level of collaboration between the Water Department and the Urban Planning Department (while such collaboration on extreme heat anticipation with social or health professionals were inexistent in this planning process). It was also very visible in the depth of the diagnostics and solutions discussed reducing vulnerabilities to water hazards in contrast to heat hazards, in the living lab workshops in which participants were invited to discuss all hazards (DS 5, workshop 1; see also Van Neste et al. 2021, 2024). When researchers emphasised vulnerability to heat, responses were predominantly about greening interventions.

Our interviews (DS 1,2) and observations (DS 4,5) suggest that it is not that urban planners favoured protection against heavy rainfall *per se*. In their professional experience, they found it imperative to have concrete data to justify stricter green regulations. Furthermore, they faced the challenge of persuading elected officials to allocate funds for land acquisition aimed at expanding public park spaces. Hence, urban planners were trying to obtain data on the necessary safeguarding of the area against flooding *in order to build a better case for strong greening constraints on urban*

development (DS 1,2,4). In addition, the innovative measures for stormwater management, like resilient water squares, were very attractive for developers (DS 1,5, workshop 3). Nonetheless, because of the technicality of these infrastructural choices, some questions were not discussed in the participatory meetings (DS 5, workshop 3), for example « How much should be invested in a foolproof 100-year-frequency rainwater square versus other investments » like parks, public spaces or community support in the neighbourhood (Van Neste et al. 2024)? What are the most relevant adaptation measures from the standpoint of residents in the greatest situation of vulnerability?

To regulate urban development in the area, planners used a special bylaw instrument called the PPU (*Programme particulier d'urbanisme*), which is embedded in the City master plan. The PPU instrument and related zoning requirements are hence the second way vulnerabilities and climate adaptation priorities were set. The bylaw institutionalised a specific area of intervention, which includes only the brownfield site, mostly “vacant land” of former industrial use and targeted for redevelopment, which became de facto the area of focus. This territory excludes the surrounding lower-income neighbourhoods, in the north-east especially, that will likely experience impacts in terms of access to services, higher property values and higher rental prices due to the redevelopment of Lachine-Est. Urban planners emphasised that while they did not see in the PPU ways to deter gentrification in the vicinity of Lachine-Est, they underscored the potential for complementary tools and collaborative efforts with neighbouring areas to be established over time (DS 4,5). Nevertheless, the concentration of efforts on enhanced green spaces and innovative initiatives such as water squares within this defined area raises concerns about the potential emergence of an affluent eco-enclave. Together, these dynamics show a prioritisation of adaptation to heavy rainfall, with an omission of considering greater social vulnerabilities to heat in the adjacent neighbourhoods, which were visible on the City's heat vulnerability map (Figure 2).

The legacies of uneven development

The government instruments and the framing of adaptation in the Lachine-Est redevelopment project selectively defined the boundaries of the territory innovating in climate adaptation, where more financial and human capital would be spent. By doing so, it also privileged a certain version of the area's history without taking stock of the legacies of past uneven development on current vulnerabilities to climate hazards.

As the water infrastructure was central to the urban redevelopment process and the definition of a vision for this future eco-district, the hydrological history of Lachine for Montreal's collective memory was also emphasised (DS 3,4,5.3). Lachine-Est was once known as the cradle of the industrialisation of Canada, with the adjacent Lachine Canal used for energy and transport (Poitras & Aubry 2004). Both heritage studies and the urban development vision hailed this history, which contributed to the attractiveness of stormwater measures as a narrative consistent with the spirit of water engineering innovation. However, the discussions barely touched on the unequal legacies of infrastructure in Lachine.

Historically, this area had been a key site for trade, living, fishing and travelling for the indigenous Kanyen'kehà:ka communities (Poitras & Aubry 2004; Rueck 2011; Toso, Spooner-Lockyer, and Hetherington 2020). In the 1820s, the lake was drained to build the Lachine Canal, while the Saint-Pierre River was eventually buried and transformed into a sewage pipe (idem). The colonial violence of this territorial transformation for Indigenous communities is not featured in the heritage narrative of the City for Lachine-Est, while the historiography and exhibits at the local Lachine museum primarily focused on the Iroquois “raids” that held up the first projected canal's construction (Toso, Spooner-Lockyer, and Hetherington 2020; the expositions are, however, being redone now).

The urban settlement of Lachine thrived thanks to industrial development, and its infrastructure (the canal and the railway) were associated with prosperity, work and progress (Poitras & Aubry 2004). In 1959, however, the St. Lawrence Seaway opened as a transportation corridor that eventually replaced the Lachine Canal, which had become too narrow and was eventually closed in

1970. This again transformed the territory of the Kanyen'kehà:ka native community living on the other shore of Lachine, cutting their direct access to the river and stealing more of their land (Rueck 2011). In addition, Lachine and Saint-Pierre (which is now a Lachine neighbourhood) suffered from deindustrialisation, with chronic unemployment, population decline, inadequate schooling and a deterioration in quality of life and the built environment (Poitras & Aubry 2004).

In the 1960s, new infrastructure arrived in the abandoned areas around the former industrial complexes. The national highway 20 was built through Lachine, with an interchange directly adjacent to the Saint-Pierre neighbourhood. The area suffers from traffic-induced air pollution and a devitalisation of the adjacent urban area and commercial street (Revitalisation urbaine intégrée 2015, 2018). Municipal authorities and community groups have been striving to revitalise the commercial artery that suffers from vacancies, high business turnover, air pollution and extreme heat. The interchange and its vehicle-oriented design also bring high volumes of cars and trucks with more traffic deaths and unsafe conditions for pedestrians (216 collisions were counted between 2012 and 2020 in one street corner next to the interchange, and two deaths in the last 3 years; Smedbol 2021; CIMA+ 2017). Yet, Saint-Pierre's residents are obliged to pass under the interchange to access buses, something they have been denouncing for years (GRAMÉ et al. 2013, RUI 2018; Smedbol 2021). Duff Court (built in the 1960s), one of the largest social housing complexes in Canada consisting of a stock of aging and unsanitary rental units (Centraide du Grand Montréal 2020), is also adjacent to the highway. Both Saint-Pierre and Duff Court are hemmed in by road and rail transport infrastructure due to past infrastructural development. These two Lachine neighbourhoods have more low-income residents, single-parent families, the elderly, renters and visible minorities than the Montreal average (Centraide du Grand Montréal 2020) – all factors considered important in the vulnerability to extreme heat. Yet, they are outside the territory chosen to intervene in Montreal's investments for the Lachine-Est resilient ecodistrict.

The legacies of uneven urban development mean that these neighbourhoods close to the new eco-district lack services, local stores and convenient access to transit, which makes the residents' experience of heatwaves all the more problematic. Interviews with residents revealed that some who did not have air conditioning took a 30 min walk to cool down at the air-conditioned pharmacy in the next neighbourhood; we also heard of not feeling safe to go cool down in public parks in Saint-Pierre. The difficult access to local services and infrastructure was raised by community organisations. Albeit aware of this issue, planners were uncomfortable discussing it in terms of climate interventions, and it did not tip the balance in the localisation of new services. The development of social resilience and access to public transit did worry the planners, but they felt that these issues were beyond their purview (especially large road and transit infrastructure, which provincial authorities are mandated for). A social perspective on climate adaptation informed by the legacies of past urban and infrastructural development seemed impractical in their everyday practices as professionals. Accordingly, the focus of their resilience planning efforts was on greening, parks, public spaces and heavy rainfall resilience.

Caring practices in neighbourhoods

Community organisations on the ground, however, need to work with these legacies of uneven development. Community groups we met observed that extreme heat greatly affects the persons they support in neighbourhoods. The urban structure produces environmental injustices which many of them spoke about when we met, in particular in relation to the difficult access to services and cool spots during heat (DS 7,8,9). But they were in majority reluctant to present themselves as 'actors' of climate change adaptation, something we unpack in this section.

Many of the community groups' activities have the potential to contribute to heat resilience. The experience of poverty, social isolation, mental illness, housing and food insecurity for which they bring support are all exacerbated by the heat (DS 7,9). Their activities, services, cultural events and grassroots greening interventions in parks and public spaces serve to provide aid, increase

capacity, diminish isolation, foster residents' relations with their communities and environment, and support the development of caring networks. Also, food aid services often represent points of entry into existing networks of care, as specific needs can be identified and redirected towards appropriate services. On the housing front, respondents identified overcrowding, unsanitary conditions and lack of ventilation as exacerbating residents' discomfort during heatwaves. Yet, housing committees protecting tenant rights have a lot to deal with and have not yet come to focus on extreme heat in their activism. In the most deprived neighbourhoods around the Lachine-Est future eco-district, the housing committee worked from an apartment 20 metres away from the highway interchange, directly experiencing the heat, noise and air pollution; but has limited resources, struggling to support all residents living in unsanitary housing conditions in the sector.

The community organisers working within local public health centres were the least shy to relate their work specifically to climate adaptation (DS 9). During heat waves, the community sector is involved in relaying information from the City and public health warning system, sending out heatwave alerts and communicating measures to prevent dehydration and reduce the risk of heatstroke. However, some respondents mentioned that this protocol has a "weak penetration level" given hard-to-reach groups such as the homeless, the elderly who lack access to the Internet, or immigrants who speak neither French nor English. In general, community groups only have the resources to reach people who attend to some of their activities or whom they visit, missing the most isolated individuals. Some groups had their own grassroots protocols in place, like groups offering support respectively to the elderly and to persons with disabilities, calling their members during heatwaves, organising visits to individual homes, or a shuttle service to air-conditioned malls. They do not have specific funding for this, and these initiatives were not known by the municipal authority.

Some initiatives specifically designed as grassroots social infrastructure for cooling were mentioned (DS 9), with one neighbourhood in particular where local community groups and shop owners mobilised to create a network of care, to facilitate access to cold water and air-conditioned premises. Street workers distribute information flyers and bottles of water to homeless persons during hot summer days. Grassroots greening initiatives were also discussed, focusing on low income neighbourhoods with an objective of increasing the sense of safety and social cohesion in neighbourhoods (DS 7,9). Other practices illustrate the capacity of community groups to adapt or maintain certain services during extreme heat. For example, offering food aid delivery service for hot summer days (to avoid heat stress during the walk to the community centre), or the distribution of water and setting up of tents to create shade during activities in the park in needs of restoration (in some cases still lacking trees and adequate water infrastructure) (DS7,9). Such initiatives illustrate the crucial role of the community sector in the maintenance of – and access to – social infrastructure within neighbourhoods.

Nevertheless, many of the community organisations we met were reluctant to consider these supportive actions and experiences as adaptation work. Heat stress was often, and sometimes exclusively, associated with the issue of mitigating the urban heat island effect, or with relaying alerts from the public health agency. This reproduced how urban planners themselves conceived of possible interventions in the face of extreme heat, and overshadowed other social support practices that also had the potential to increase heat resilience. While several actors were convening together to build a resilient ecodistrict in Lachine-Est, the inequities and marginalisation experienced in surrounding neighbourhoods did not fit in the story and framing of adaptation.

During our focus group in Lachine (DS 8), community organisers were very interested in our diagnosis of how their actions contributed to reducing vulnerabilities to heat. But they already have a lot on their shoulders, and the municipal initiatives for resilience and increasing capacity have focused more on information campaigns, outreach with police officers and punctual support for community initiatives outside the Lachine borough. For the community groups we met, the projected increase in days of extreme heat was of considerable concern. The impacts of the pandemic lockdown were also mentioned by many (DS 7,9), with the aggravation of vulnerabilities among the persons they

support: exacerbation of social isolation, loss of mobility, greater food insecurity (associated with loss or reduction of income) and the degradation of health conditions, to name a few. However, many pointed to a lack of resources to develop adaptation and support projects: “We have no budget! We work with peanuts, the community sector.” (community organizer, DS 9). A sense of indignation combined with powerlessness resonated in some respondents’ words and tone when recalling situations of pronounced vulnerability they witnessed.

Conclusion

The discourses surrounding urban adaptation and resilience have faced criticism for often obscuring the underlying factors that lead to the need for resilience in the first place: namely, economic, social and ecological crises, and the dynamics of uneven development (including planning choices) that create precarity (Long and Rice 2019; Bracke 2016). Our paper aims to conceptually outline and empirically investigate the processes and instruments involved in the urban politics of adaptation, which marginalise the socially produced drivers of vulnerability to extreme heat. In other words, we are not solely interested in how vulnerability manifests itself, but rather in why the production of vulnerability persists, why this is not acknowledged and how to act upon it (Mikulewicz 2018).

To truly enable transformative adaptation, we think we must go beyond the content of climate plans, to understand the everyday urban politics of adaptation and seek points of intervention. By engaging a conversation between the literature from critical adaptation and urban studies, we arrive at three processes that seem to contribute to the invisibilization of the social production of vulnerability. First, the framing of adaptation and the implicit assumptions, choices, and normative visions embedded within formal adaptation practices and instruments. Climate adaptation plans in cities of the Global North often neglect the social and chronic dimensions of vulnerability, instead concentrating on efforts to green the built environment or organise health emergency responses and information campaigns. Second, heat is rarely framed as an issue of equity, and the vulnerabilities produced by uneven development are not recognised. Third, the different experiences of heat and caring practices are marginalised or rendered irrelevant. The understanding of these three processes enables our results to resonate with other cities beyond Montreal. Although the specific context and politics will determine their outcomes in each case, we need to be attentive to these trends.

Our examination of the instruments used in Lachine, Montreal reveals clear biases and pitfalls in the prioritisation of territories, hazards, and populations. The municipal water department wields significant influence over climate adaptation decisions in Montreal, a phenomenon also observed in other North American cities (Finewood et al. 2019; Meerow 2020). Their power to choose where municipal investments are made in order to enable development has resulted in a prioritisation of adaptation that, at best, treats municipal adaptation to heat as a co-benefit of innovative green stormwater infrastructure. This is reinforced by a selective heritage celebration of hydraulic innovation and industrial progress along the Lachine Canal. The second instrument implemented was the bylaw that designated the brownfield site, as the area to be redeveloped, as the focal point for investment and expertise. This planning choice further exacerbates the existing inequalities that already exist.

However, we do recognise that unpacking the underlying norms and assumptions of these practices with practitioners, alongside addressing the power dynamics and financial relationships that shape them, demands sustained efforts and enduring relationships, which we are committed to cultivating locally. More equity-driven adaptation efforts and instruments are being discussed today, including initiatives from both community actors and the City to tackle inequalities in services and investments in the adjacent Saint-Pierre neighbourhood.

Generally, the ways in which the historical and ongoing uneven production of space affects vulnerabilities to climate hazards are rarely acknowledged in urban climate adaptation discussions

(Castán Broto 2021). For sure, adaptation decisions shape future pathways for adaptation in determining what appear feasible and even natural, both materially and politically. Henrique and Tschakert (2020) rightly alert us to the cycles of dispossession which adaptation can be associated with. Recognising history involves acknowledging ongoing harms, as well as preserving and restoring capacities to adapt and transform society (Castán Broto 2021; Lampis et al. 2022). Unfortunately, care and social infrastructure remain undervalued in our society, including in the realm of adaptation where they are critically needed (Amorim-Maia et al. 2024; Teebken 2024). An ethic of care is intrinsic to achieving justice in the city, raising awareness about everyday practices that contribute to repairing our world and foster “care-full adaptation” (Bond and Barth 2020; Williams 2017). We urge urbanist and critical adaptation scholars and practitioners to continue their ongoing conversations, especially on how the urban governance of climate adaptation can better support an ethic of care and address the root causes of heat vulnerability.

Notes

1. Used 29% of the times, in the survey results from Meerow and Keith (2022).
2. Not anticipated in the Lachine borough.
3. See Acknowledgments.
4. These interviews were exploratory and were mostly used to start the conversation with community groups from the local experience of residents; it is more the experience of community groups that we use and analyse in this article.

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Ethics approval statement

This research has been reviewed by the INRS Committee of Ethics in research with humans, ID CER-19-510.

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