



REVIEW

Towards environmental health equity in health impact assessment: innovations and opportunities

Chris G. Buse¹ · Valerie Lai² · Katie Cornish¹ · Margot W. Parkes¹

Received: 15 December 2017 / Revised: 5 June 2018 / Accepted: 7 June 2018 / Published online: 18 June 2018
© Swiss School of Public Health (SSPH+) 2018

Abstract

Objectives As global environmental change drives inequitable health outcomes, novel health equity assessment methodologies are increasingly required. We review literatures on equity-focused HIA to clarify how equity is informing HIA practice, and to surface innovations for assessing health equity in relation to a range of exposures across geographic and temporal scales.

Methods A narrative review of the health equity and HIA literatures analysed English articles published between 2003 and 2017 across PubMed, PubMed Central, Biomed Central and Ovid Medline. Title and abstract reviews of 849 search results yielded 89 articles receiving full text review.

Results Considerations of equity in HIA increased over the last 5 years, but equity continues to be conflated with health disparities rather than their root causes (i.e. inequities). Lessons from six literatures to inform future HIA practice are described: HIA for healthy cities, climate change vulnerability assessment, cumulative health risk assessment, intersectionality-based policy analysis, corporate health impact assessment and global health impact assessment.

Conclusions Academic reporting on incorporating equity in HIA practice has been limited. Nonetheless, significant methodological advancements are being made to examine the health equity implications of multiple environmental exposures.

Keywords Health impact assessment · Health equity · Impact assessment methodology · Environmental determinants of health

Introduction

Health impact assessment (HIA) has expanded over the past 30 years and now comprises an array of research methods, tools and processes capable of unpacking and evaluating the human health impacts of policies, programmes and development projects. HIA is typically comprised of six stages: screening, scoping, assessment or appraisal, recommendations, reporting and monitoring/

evaluation (WHO 2007; Center for Disease Control 2017). However, assessment techniques such as HIA or environmental impact assessment (EIA) are increasingly criticized for narrowly ‘screening’ or ‘scoping’ assessment procedures towards the impacts of a single project or policy (Gillingham et al. 2016). This raises important questions for HIA practice, as health is increasingly recognized to be located at the confluence of complex webs of proximal and distal determinants which increasingly include ecosystem-based and planetary drivers of health and well-being (Barton and Grant 2013; Parkes 2016). Thus, HIA practice is increasingly challenged to appropriately address the complex ecological drivers of health and illness in the twenty-first century which increasingly include climate change, ecosystem degradation, intensifying resource development activities and rapid urbanization.

Further, health equity is increasingly identified as a core value of HIA practice (Wise et al. 2009; Heller et al. 2014; Povall et al. 2014), and many of the health impacts of

This article is part of the special issue “Environmental and health equity”.

✉ Chris G. Buse
chris.buse@unbc.ca

¹ School of Health Sciences, University of Northern British Columbia, Prince George, BC, Canada

² Faculty of Medicine, University of British Columbia, Vancouver, Canada

global environmental change are likely to be experienced by vulnerable populations, posing significant challenges to the exacerbation of existing health inequities (Corvalan et al. 2005). Yet, there is limited agreement as to which methodology or suite of approaches for analysing the relationship between environmental change and well-being is more or less robust (Braubach et al. 2015). Instead, many HIAs tend to incorporate a ‘social determinants of health’ framing to the impacts of a given project, despite increasing recognition that the confluence of a singular project with other stressors can influence health equity across space and time (Parkes 2016).

In order to document novel conceptual developments for engaging with the health equity impacts of ecological drivers of health and wellness, we conducted a review of the equity-focused HIA literature to: (1) examine the degree to which equity has been incorporated into HIA conceptual design; (2) explore practical recommendations on the conduct of equity-focused HIA that have emerged in contemporary literatures; and (3) identify nuanced tools and related methods that provide guidance on assessing the spatial and temporal dimensions of health equity from multiple exposures. The remainder of the paper presents our search protocol, results, and highlights six areas of HIA innovation.

Methods

We conducted two parallel searches for peer-reviewed articles published between 2003–2017 across four public health literature databases: PubMed, PubMed Central, Biomed Central and Ovid Medline (see Fig. 1) following established literature review protocols (Grant and Booth 2009; Wiles et al. 2011). The first search utilized the terms “‘equity’ and ‘health impact assessment’” and the second “‘health equity’ and ‘impact assessment’” which identified 849 articles. After removing 145 duplicates, a title and abstract review was conducted to select papers that: were written in English, focused on high-income countries, and highlighted methodological development of equity-focused HIA. This included identifying articles offering innovative approaches or frameworks for accounting for multiple spatial and temporal scales that influence drivers of health equity.

In this paper, temporal dimensions of scale refer to past, present or possible future interactions between an exposure or multiple exposures influencing the health and/or well-being of past, present and future individuals or populations. Temporality should explicitly take into account the relationships among exposures, hosts and environments at various points in time which may conflate or exacerbate health equity. Spatial dimensions of scale refer to the

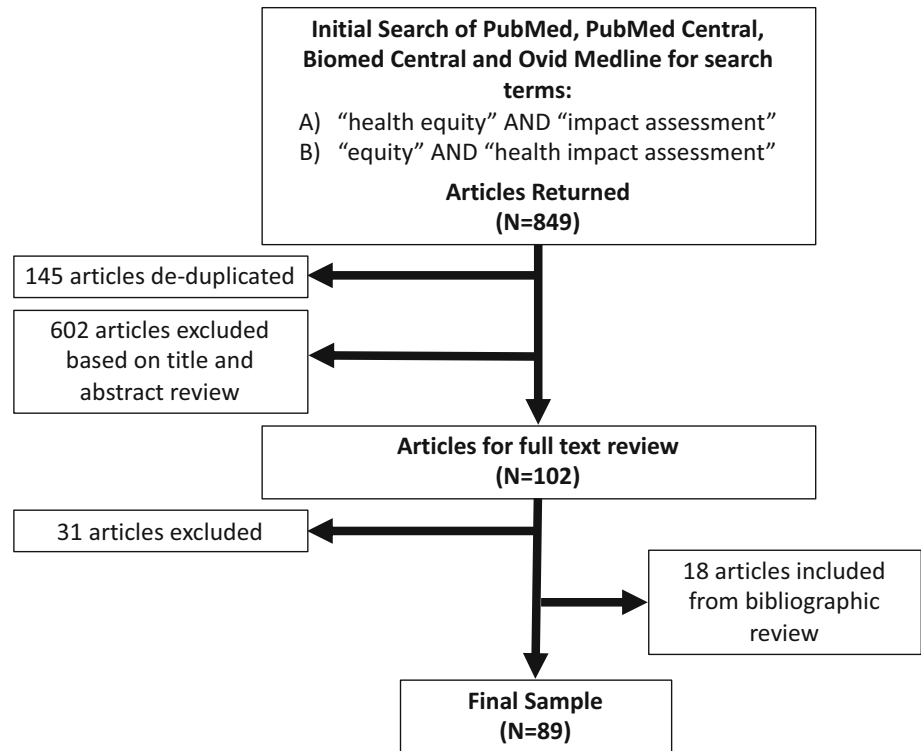
geographic boundaries by which an assessment protocol is defined (e.g. neighbourhoods, entire cities, broader geopolitical regions, or ecological boundaries such as watersheds or airsheds). Spatial scale encourages us to think about the distribution of multiple exposures or health outcomes across a pre-defined space, and additional factors within that space that may have pre-existing influence over the determinants of health, thereby affecting baseline measurements during the screening and analysis phase of an HIA.

Inclusion and exclusion criteria for our sample were assessed by two members of the research team, and all inclusion/exclusion decisions were reviewed by a third team member. If there was disagreement on the inclusion or exclusion of a particular article, the full text was reviewed and a discussion among team members led to a final decision. We excluded 602 articles based on this process (see Fig. 1). The full text of 102 articles was then read by three members of the research team where an additional 31 articles were deemed out of scope. A bibliographic review of reference lists of each article surfaced additional peer-reviewed resources that were included in our sample ($N = 18$). An annotated bibliography was generated for each identified article in the final sample ($N = 89$) based on combined researcher notes on the articles that clarified the intent of the article, its conceptual contribution to equity-focused HIA, and any relevant key findings. The combined annotations informed coding, analysis and narrative review. Coding was used to identify the orientation of articles to health equity: differentiating those articles that articulated health equity as rooted in principles of fairness and justice, from those which simply categorized population groups as more or less at risk, or those experiencing a greater burden of particular health outcomes (i.e. unequal patterns of health outcomes across population groups). Coding also identified articles that provided conceptual clarification on HIA-related practice, and associated innovations in assessing health impacts across broader spatial and temporal scales. A spreadsheet was created in parallel to the annotation process to code articles and generate counts according to the particular foci of each article or subgroups of articles. A narrative review process (Clandinin 2006; Green et al. 2006) was utilized to distil key insights through analysis of articles providing conceptual clarification on incorporating equity into HIA practice, and to characterize the range of innovative assessment approaches emerging within HIA-informed techniques.

Limitations

Two principle limitations arise from our methodological approach. First, we only reviewed English articles, thereby

Fig. 1 Title and abstract search protocol for peer-reviewed articles addressing health equity in health impact assessment: results from a literature review of English language articles published between 2003 and 2017



limiting possible contributions from a range of non-English contributions. We acknowledge this limitation with the hopes that readers will be able to identify additional approaches to equity-focused HIA through correspondence or future research. Second, we did not conduct a full appraisal of the quality of the evidence of each of the 89 articles that comprised our sample. This decision relates to: (1) the content of our sample which included an array of scholarly outputs ranging from empirical research on the implementation of HIAs to conceptual commentaries on HIA practice; and (2) the appropriateness of our narrative review method to distil key learnings from identified articles. This decision is consistent with the intent of this review to surface lessons and opportunities for methodological innovation from a diverse array of HIA-related literatures, rather than determining which literatures have more or less robust evidence.

Results

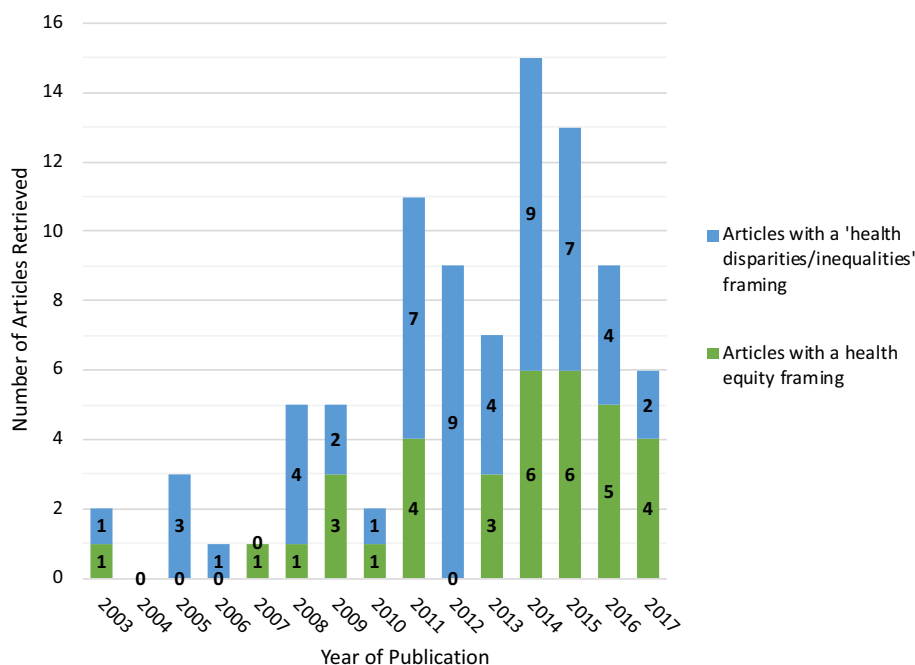
Our review found that a majority ($N = 70$) of identified articles were published in 2011 or later (78.7% of our sample), with 19 (21.3%) being published in 2010 or earlier. Only 35 articles (39.3%) included a central emphasis on health equity, whereas the remaining 54 articles (60.7%) were oriented to measuring population health disparities and inequalities, including the differential distribution of

health impacts according to the issue under analysis (see Fig. 2).

Irrespective of the particular orientation to health equity, several recurring principles were identified across the entire sample that have relevance to deploying HIA with an equity focus. These include that HIAs: have clear goals; include early involvement from intersectoral decision-makers and those most affected by the issue(s) under analysis to gain trust and enhance uptake of results; make the assessment cost-effective; deploy simple language so the HIA can be understood by a variety of actors across sectors; include a range of evidence; be guided by an appropriate and transparent conceptual framework; be adequately resourced; and utilize indicators that are easily measured and available to policy makers (Fakhri et al. 2014; Winkler and Utzinger 2014). We also found evidence that HIAs can promote health in all policies agendas and can be used to mobilize community advocacy and promote environmental health justice (Bhatia and Wernham 2008; Prochaska et al. 2012; Hirono et al. 2016; Pies et al. 2016). However, to realize this potential, decision-makers must be included in the design and implementation of the HIA, receptive to its findings and interested in achieving health equity (Yuen and Payne-Sturges 2013; Harris-Roxas et al. 2014).

Additionally, 26 of the articles (29.2%) report on the results of an HIA that was implemented, and of those, only 15 held equity as a central focus, six of which were

Fig. 2 Yearly distribution of health impact assessment comparing articles with an equity framing to those with a health disparities/inequalities framing: results from a literature review of English language articles published between 2003 and 2017 ($N = 89$)



published in 2011 or earlier, and nine of which were published after 2014. These findings demonstrate that equity is becoming increasingly mainstreamed as a guiding concept in HIA theory and practice (Heller et al. 2014), and suggest that as HIA becomes more popular in use, the concept of health equity has proliferated alongside the deployment of HIAs more generally. However, results depicted in Fig. 2 also demonstrate that, within the equity-focused HIA literature, the concepts of health inequalities/disparities and health equity are both in active use and are also likely to be conflated in ways that could limit intended orientations to justice and fairness in HIA processes.

Areas of practical innovation in health impact assessment: accounting for the broad temporal and spatial distribution of multiple risks to health equity

Our review surfaced 53 articles that provide methodological guidance on measuring health equity to account for multiple risks, hazards or impacts across a range of spatial and temporal scales, thereby enabling researchers to move beyond the singular project or exposure focus that limits many HIAs. Table 1 presents these 53 articles, along with the findings from coding and review of their principle contributions which identified six key developments in HIA practice: HIA for healthy cities and urban planning issues ($N = 24$); cumulative health risk assessment ($N = 13$); corporate health impact assessment ($N = 6$); climate change-focused HIA ($N = 5$); intersectionality-based assessment ($N = 4$); and global health impact

assessment ($N = 1$). Figure 3 provides a graphical depiction of the emergence of these literatures over time, and that most of these developments were published between 2011 and 2015. Findings from our narrative review elaborate on key characteristics of the six literature categories, and their contributions to help inform future HIA practice.

HIA for healthy cities and urban planning

Our review indicates that HIA methods are increasingly directed spatially towards entire urban areas to promote healthy cities (Mathias and Harris-Roxas 2009; Kumaresan et al. 2010; Ross et al. 2012; de Leeuw 2012, 2013; de Blasio et al. 2012; Schaff et al. 2013; Ison 2013; Simos et al. 2015; Tuomisto et al. 2015; Pennington et al. 2017). Of the 89 articles that received full text review, 24 were focused on an array of issues affecting urban areas including traffic-related pollution and noise, crime, and environmental justice issues in inner city neighbourhoods. Each of these articles indicate that at the level of analysis of a neighbourhood, community or city, HIA can be a useful mechanism for driving local planning decisions that may span decades, and that multiple urban environmental health exposures can be accounted for in HIA.

Our review uncovered multiple HIA frameworks HIA emphasizing equity in urban spaces (e.g. HEAT, DYNAMO-HIA, equity-focused HIA and health equity impact assessment among others). The proliferation of 'new' frameworks seems to be primarily based on reiterations or reformulations of the six-step approach to conducting HIA. Lessons from these literatures include the

Table 1 Overview of six literature categories providing innovations and opportunities for the spatial and temporal measurement of health equity in health impact assessment practice: narrative literature review of English language articles published between 2003 and 2017 ($N = 53$)

Thematic area	Opportunities related to incorporating equity into health impact assessment	Supporting citations
Health impact assessment for urban planning ($N = 24$)	Health impact assessment can be effectively leveraged for city-wide areas to influence planning decisions with long time horizons. Health impact assessment can also successfully account for multiple urban environmental health exposures and their interaction with social determinants of health	Braubach et al. (2015), Corburn (2017), de Blasio et al. (2012), de Leeuw (2012, 2013), Dora and Racioppi (2003), Farhang et al. (2008), Ison (2013), James et al. (2014), Johnson Thornton et al. (2013), Kjellstrom et al. (2007), Korfmacher et al. (2015), Kumaresan et al. (2010), Mansfield and MacDonald Gibson (2015), Martenies et al. (2015), Mathias and Harris-Roxas (2009), Nadrian et al. (2014), Pennington et al. (2017), Ross et al. (2012), Schaff et al. (2013), Serrano et al. (2016), Simos et al. (2015), Tuomisto et al. (2015), Wier et al. (2009)
Cumulative risk assessment ($N = 13$)	Models for assessing the additive and multiplicative health risks of two or more exposures can be effectively utilized to understand the distribution of health outcomes and health equity across time and space	Betts (2012), Buck and Sundaram (2012), Chiu et al. (2013), Corburn et al. (2014), Cote et al. (2012), Hickens et al. (2011), Juarez et al. (2014), Krewski et al. (2014), Prochaska et al. (2012), Sartorius (2013), Sexton and Linder (2010, 2011), Wild (2012)
Corporate health impact Assessment ($N = 6$)	Considers the activities of a singular corporate entity's activities across the multiple locations in which that entity holds offices or operates. Can be successfully applied to a 'cross border' analysis of health issues resulting from corporate practices that affect localities in different ways based on contextual conditions	Anaf et al. (2017), Baum et al. (2016), Freudenberg and Galea (2008), Friel et al. (2013), Monteiro and Cannon (2012), Stuckler et al. (2012)
Health impact assessment for climate vulnerability ($N = 5$)	Health impact assessment has been successfully deployed to understand climate risks to health equity at the level of neighbourhoods, cities and airsheds, and can provide programmatic guidance for public health agencies into the future as climate impacts to health equity continue to affect vulnerable populations	Brown and Spickett (2014), Brown et al. (2014), Hambling, Weinstein and Slaney (2011), Houghton and English (2014), Spickett et al. (2011)
Intersectionality-based policy assessment ($N = 4$)	Life course analysis and critical qualitative and quantitative analysis methods can be combined to facilitate an understanding of the interaction between various social determinants of health and their influence on health equity across time	Bishwakarma et al. (2008), Hankivsky et al. (2014), Hankivsky and Cormier (2011), Sen et al. (2009)
Global health impact assessment ($N = 1$)	Health impact assessment can theoretically be applied to any geographic area so long as the boundaries of the assessment are justified. Global health impact assessment focuses practitioners' gaze towards global scale impacts of national level policies	Mwatsama et al. (2014)

importance of: incorporating data and information that can reflect changing population characteristics over time which are reflective of equity goals outlined in an assessment (Mansfield and MacDonald Gibson 2015); co-producing research through collaborative processes that build trust and buy-in from decision-makers, and which address myriad determinants of health and the influence of environmental conditions (Kjellstrom et al. 2007; Farhang et al. 2008; Weiss et al. 2016); leveraging other strategic initiatives that attempt to redress structural inequities and guide suitable interventions such as the sustainable development goals (Corburn 2017); and utilizing health arguments to strengthen environmental decisions and harmonize inter-jurisdictional project development (e.g. transportation

strategies) (Dora and Racioppi 2003; James et al. 2014; Nadrian et al. 2014; Korfmacher et al. 2015).

Cumulative health risk assessment

Thirteen articles focused on cumulative health risk assessment (CHRA) as a mechanism to enhance HIA. Designed to assess the overall risk burden of multiple environmental exposures, CHRA typically combines data on biomarkers, toxicity pathways (e.g. hazard identification and dose–response) and a variety of social determinants of health to attempt to determine how additive pressures of multiple projects exacerbate health inequities over time (Prochaska et al. 2012; Krewski et al. 2014). These papers

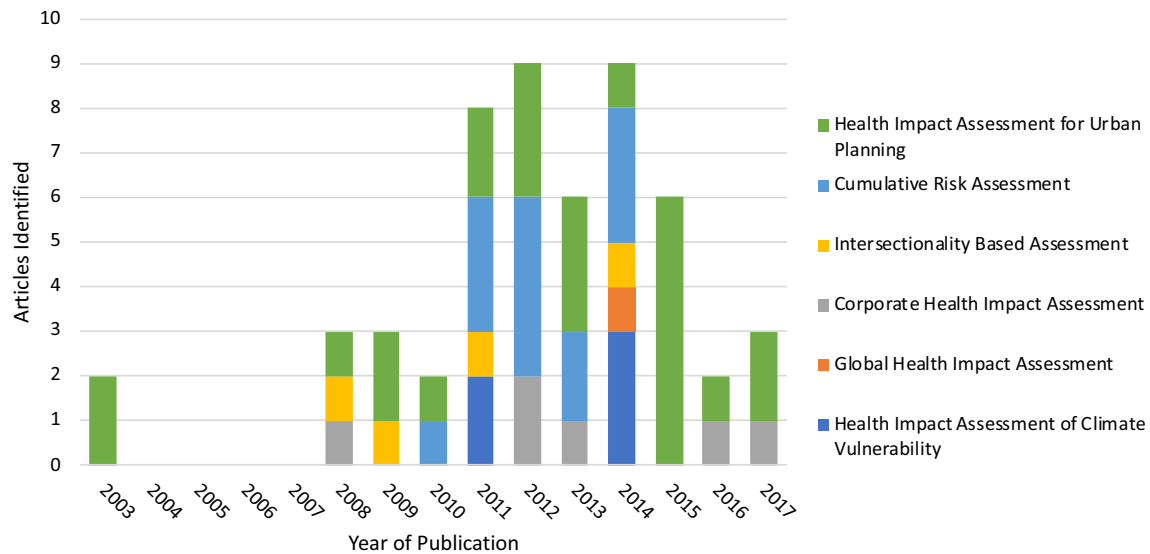


Fig. 3 Yearly distribution of health impact assessment articles according to six identified literature categories offering innovative approaches that account for multiple exposures across time and space:

results of a narrative literature review of English language articles published between 2003 and 2017 ($N = 53$)

tend to focus on toxic exposures and share new risk analysis methods that explicate how vulnerable populations may face unjust exposures to poor air quality or hazardous waste which can exacerbate health inequalities.

A burgeoning area of investigation in CHRA is the Public Health Exposome—an emerging “big data” approach to biomonitoring with thousands of variables and data on various environmental exposures that can occur throughout an individual’s life time, organized across different health disparities (e.g. cancer, cardio-metabolic disease, HIV/STIs, injury, maternal and child death, and mental health and substance abuse (Juarez et al. 2014)). Measures relate to morbidity, mortality, health behaviours and screening rates, and enable multi-modal analytic approach, combinatorial analysis and spatial–temporal analysis of environmental exposures over time (Juarez et al. 2014). Advocates of the Public Health Exposome believe that the continued use of exposome information can improve study design (Chiu et al. 2013), strengthen cumulative risk models (Cote et al. 2012; Sexton and Linder 2010, 2011) and advance exposure characterization in HIA practice by providing historical exposure data for entire populations for which data may be available (Buck and Sundaram 2012; Wild 2012).

Corporate health assessment

Corporate health impact assessment (CHIA) is a framework and equity-focused HIA methodology to assess the political, economic and regulatory contexts at the global, national and subnational levels, attending specifically to existing HIA, environmental impact assessment (EIA) and

corporate social responsibility regulatory mandates. CHIA analyses the structures, practices and products of a corporate entity including business practices, political activities, and marketing impacts, and how those processes influence health equity across global and national contexts. Specific impacts for analysis may include those to workforce and work conditions, social impacts, impacts to the natural environment and health-related behaviours and economic changes (Baum et al. 2016). Central to CHIA is the notion that appropriate risk mitigation activities from corporate activities may influence human health through global trade, capital investment, and influence over national, regional or local economies (Freudenberg and Galea 2008; Monteiro and Cannon 2012; Stuckler et al. 2012). CHIA tends to follow similar steps as conventional HIA. CHIA enables the tracking of impacts across geographic spaces where a single corporate entity may be operating, whereby transnational corporations are viewed as an institution as opposed to a single industry, corporation or project. CHIA has been successful at articulating the potential cumulative health impacts of policies, plans, projects and services related to corporate activities (Anaf et al. 2017).

HIA for assessing climate change impacts on health vulnerabilities

Five articles focused specifically on assessing health vulnerability from climate change. While typically applied at the level of an urban area (i.e. a city), this literature signifies that HIA tools are being directed towards more complex environmental health phenomena. Through the scoping and identification of health risks, ranking risks

according to local health priorities, and identifying suitable adaptation measures, researchers become better situated to make recommendations that build adaptive capacity for extreme climate events in the future, while also documenting baseline health impacts (e.g. vectorborne disease, heat health, and respiratory disease from air quality) already being affected by climate change (Brown et al. 2014; Spickett et al. 2011).

Findings indicate that if utilized as part of a formal planning process, developing environmental health indicators related to climate change can ensure that future interventions do not exacerbate identified inequalities (Houghton and English 2014). It can also elucidate ways in which compounding climate change activities (e.g. from storm surges and extreme heat) can be mapped and modelled utilizing geospatial tools and monitored over time and overlaid with data on a variety of determinants of health (Brown and Spickett 2014). Similarly, HIA methods in this field have become adapted to identify relationships between local health and globally relevant driving forces of ecological pressures.

HIA frameworks for climate change vulnerability require consideration for both direct and indirect effects of climate events including: environmental/ecological, socio-economic, psychosocial, lifestyle, technological, and service impacts related to community context (Brown et al. 2014). This necessitates the careful selection of stakeholders from key areas to participate in the development and implementation of the assessment—which should be rooted in clear statements of collaboration and communication, including: health, emergency services, environment, indigenous affairs, planning, housing, water, community development, energy, transport and agriculture. Evidence exists to support that HIA methods, when applied to climate change, have seen some success in enabling researchers to expand the purview of an HIA beyond a single geographic unit of analysis, incorporate diverse stakeholders into the assessment process, and to explore the development of environmental health indicators that are consistent and comparable across time and space (Hambling et al. 2011).

Intersectionality-based policy analysis framework (IBPA)

The IBPA framework was developed through a participatory process inclusive of multiple sectors that “is intended to capture and respond to the multi-level interacting social locations, forces, factors and power structures that shape and influence human life and health” (Hankivsky et al. 2014, p. 1). IBPA provides an innovative framework for critical analysis of health equity by elucidating the multiple contexts (e.g. histories, politics, everyday lived experiences and intersecting social identities) affected by policy and

programme decisions and seeks to provide transformative recommendations that are focused on redressing health inequities (Sen et al. 2009; Bishwakarma et al. 2008).

The IBPA is guided by eight overarching principles: intersecting categories, multi-level analysis, power, reflexivity, time and space, diverse knowledges, social justice and equity. It deploys twelve specific questions oriented towards descriptive and transformative understandings of a particular policy issue. Descriptive questions seek to build inclusive representations of the “problem” under consideration, how that problem has been framed in the past, who is affected by the problem, and to characterize existing policy responses. Transformative questions are geared towards detailing what inequities exist in relation to the problem, where and how interventions can be leveraged to reduce inequities through short, medium and long-term solutions, how implementation can be assured, how best to monitor the reduction in inequities, and how the process of engaging in IBPA might transform decision-maker relationship to power and equity in the work of policy development, implementation and analysis. Thus, IBPA has the potential to explore the confluence of determinants or exposures over the life course in ways that may be transformative for decision-makers who were previously unaware of compounded or cumulative vulnerability in their region.

Global health impact assessment

HIAs rarely extend to understanding impacts of national policy decisions on international contexts (Mwatsama et al. 2014). Global health impact assessment (GHIA) was designed “to assess the impact on health and social determinants of health of a particular country’s policies on populations in low and middle-income countries” (Mwatsama et al. 2014, p. 2). GHIA significantly broadens the focus of HIA to include multiple national and regional policy contexts. Following similar steps as those in HIA, the screening phase is expanded to consider what, if any impacts from national-level policy may lead to changes across a variety of possibly global, regional, national and subnational levels, with the purpose of promoting equitable and sustainable development for all. Similar to guidance on HIA more generally, a key to success is to involve a variety of state and non-state actors, with civil society actors being identified as a key stakeholder in representing global voices and to drive external demand for GHIA.

Discussion

Many drivers of environmental health affect broad spatial areas with impacts unfolding over time periods of decades or even centuries compared to the relatively short tenure of some policies or projects. This informs a sense of urgency around the need for health actors to engage in longer-term planning horizons as the impacts of global environmental change continue to unfold and present both predictable and unpredictable challenges for health equity agendas through the remainder of the twenty-first century (Campbell-Lendrum and Corvalán 2007).

The results above demonstrate how HIA-related assessment techniques increasingly address equity issues. By equity, we refer to health outcomes that ought to be fair or just, as compared to health disparities or inequalities which refer to the differential distribution of health outcomes across population groups (Braveman 2006; Kawachi et al. 2002). We found that incorporating equity considerations into HIA practice is well-established in principle and reflected through the growing proliferation of equity-focused articles over time. However, more than 60% of the articles in our sample were primarily concerned with the analysis of differential health outcomes according to population status (e.g. race/ethnicity, gender, class, etc.). We believe this results from conventional guidance on the ‘scoping’ phase of HIA where a stated goal is to conceptualize populations or specific groups of people that are more or less affected by the ‘problem’ under analysis (WHO 2007). The specific focus on identifying vulnerable groups or those more likely to be impacted by a programme or policy is therefore likely to engender a distributional understanding of equity in terms of unequal health outcomes, a priori of whether these outcomes are *fair* or *just*.

Thus, there were many examples of HIA that claim to attend to equity, but which conflate an analysis of the social determinants of health with equity by disaggregating populations into more or less vulnerable groups. The fact that more than half of the articles we reviewed merely conceptualize differential health impacts in keeping with a health inequalities/disparities orientation poses a caution for equity-focused HIA, and fuels the need for HIA approaches that, instead, expose the root causes of inequalities (i.e. inequities) and foster methodological strategies to address the relationships between inequality and inequity (Braveman and Gruskin 2003; Marmot 2007).

Further, we found that much of the literature reviewed privileged quantitative rather than qualitative information in assessment processes (with the exception of intersectionality-based assessment methods) and are still more often conducted by academic or civil society groups outside of formal decision-making processes—although some

assessments may be done with the direct or indirect involvement of decision-makers. Nonetheless, the six literatures identified above demonstrate methodological developments towards understanding global environmental driving forces, their interface with a variety of locally, regionally and internationally contextualized determinants of health, and their implications for health outcomes.

While there is clearly an urban bias in many of the HIA-related assessments surfaced in our review, several tools (including GHIA and CHIA) encourage researchers to consider the multiple jurisdictions and myriad policy contexts at play when considering transboundary health challenges. We also draw inspiration from new models and frameworks for assessing cumulative risks of multiple exposures. However, the CHRA literature we surfaced is largely targeted towards toxic exposures for building additive models of exposure in an attempt to determine the attribution of one stressor relative to another. Future areas of research should attempt to model additive relationships, but also multiplicative or inhibitory effects that are reflective of the complex relationships and feedback loops present among ecological drivers of change and human health (Parkes 2016).

Increased attention towards the integration of diverse pathways to health and wellness (i.e. the ecological/environmental, political, social, economic and cultural determinants) is also required to better account for attributable impacts of a given project in relation to the accumulation of health impacts over time which are reflective of changing baseline conditions in a given study area. As methods of understanding attribution of specific stressors to health improve, it will be important to recognize that equity issues can become backgrounded—even when considering community socio-economic and health priorities—in assessment processes due to common pitfalls such as lack of data or interest in ensuring equity is a value that is championed and maintained throughout an assessment.

Moving the assessment methods identified here (e.g. HIA, EIA) towards *integrated* assessment of environmental, community and health issues offers significant potential to understand multiple drivers, pressures and impacts to ecosystems, communities and human health (Briggs 2008). Integrated assessment approaches may yield added benefits of bringing together diverse teams of problem solvers and decision-makers, developing common agendas and goals across sectors, and clarifying the interrelationships and sometimes conflicting goals of multiple parallel assessment processes and their recommended risk mitigation strategies. Given the central importance of involving diverse stakeholders in any assessment process, developing new suites of integrated assessment approaches has a high

degree of likelihood to bolster intersectoral working arrangements and long-term partnerships.

Considerable challenges remain in terms of implementing more nuanced approaches to assessing the health equity dimensions of environmental change. Many of the assessment processes above (including HIA) are not mandatory nor institutionalized in many countries around the world and thus may suffer from a lack of staff, time, resources and competing priorities (Shankardass et al. 2015; Haigh et al. 2015). Indeed, HIA methods tend to be part of regulatory processes such as EIA in many parts of the world, and even then, few countries may require any form of HIA. Moreover, few regulatory regimes require an equity focus, let alone advocate for specific methods that provide guidance on wicked ecological challenges where associated drivers, effects and impacts require nuanced understanding across spatial scales and over time horizons that typically outlast any single policy cycle. The challenge of proper participation and intersectoral collaboration on wicked ecological challenges, when balanced for the need for timely and efficient assessment methods raises a significant degree of analytic complexity and the requirement of significant human resource capacity and expertise to conduct integrated assessment appropriately (Mahboubi et al. 2015). As relatively new methodologies, approaches such as CHRA, CHIA, GHIA or even climate change vulnerability assessments may not have the kind of cachet with decision-makers that allow their full potential to be recognized.

However, increasing calls for health in all policies and environment in all policies (Browne and Rutherford 2017) signal the need to merge common agendas in the protection and promotion of both ecological and public health (Parkes 2012). Given the cross-cutting features of how ecological, ecosystem, environmental changes increasingly require consideration as drivers of equity issues, the literatures reviewed here signal promising opportunities for more nuanced approaches to understanding the equity dimensions of multiple environmental exposures and their impacts across time and space.

Conclusion

This review has broad implications for the development of innovative techniques and opportunities for evaluating a variety of health equity issues related to emerging environmental challenges in the 21st CE. As ecological drivers of health and well-being are increasingly recognized to be driving health equity issues, new integrative suites of tools and processes are required to understand and respond to the confluence of numerous determinants of health, and on a fundamentally different temporal and spatial scale than

most HIAs are typically concerned. We believe that areas of scientific advancement addressing multiple exposures offer exciting possibilities to grow the potential of HIA (and equity-focused HIA) given the necessity of incorporating broader spatial and temporal scales of assessment.

Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare.

References

- Anaf J, Baum FE, Fisher M, Harris E, Friel S (2017) Assessing the health impact of transnational corporations: a case study on McDonald's Australia. *Glob Health* 13:7. <https://doi.org/10.1186/s12992-016-0230-4>
- Barton H, Grant M (2013) Urban planning for healthy cities. *J Urban Health Bull N Y Acad Med* 90:129–141. <https://doi.org/10.1007/s11524-011-9649-3>
- Baum FE, Sanders DM, Fisher M, Anaf J, Freudenberg N, Friel S, Labonté R, London L, Monteiro C, Scott-Samuel A, Sen A (2016) Assessing the health impact of transnational corporations: its importance and a framework. *Glob Health* 12:27. <https://doi.org/10.1186/s12992-016-0164-x>
- Betts KS (2012) Characterizing exposomes: kecc tools for measuring personal environmental exposures. *Environ Health Perspect* 120:158–163
- Bhatia R, Wernham A (2008) Integrating human health into environmental impact assessment: an unrealized opportunity for environmental health and justice. *Environ Health Perspect* 116:991–1000. <https://doi.org/10.1289/ehp.11132>
- Bishwakarma R, Hunt VH, Zajicek A (2008) Beyond one-dimensional policy frameworks: a practical guide for an intersectional policy analysis. *Himalaya Res Bull* 27(1–2):19–30
- Braubach M, Tobollik M, Mudu P, Hiscock R, Chapizanis D, Sarigiannis DA, Keuken M, Perez L, Martuzzi M (2015) Development of a quantitative methodology to assess the impacts of urban transport interventions and related noise on well-being. *Int J Environ Res Public Health* 12:5792–5814. <https://doi.org/10.3390/ijerph120605792>
- Braveman P (2006) Health disparities and health equity: concepts and measurement. *Ann Rev Public Health* 27:167–194
- Braveman P, Gruskin S (2003) Defining equity in health. *J Epidemiol Community Health* 57:254–258. <https://doi.org/10.1136/jech.57.4.254>
- Briggs DJ (2008) A framework for integrated environmental health impact assessment of systemic risks. *Environ Health* 7:61. <https://doi.org/10.1186/1476-069X-7-61>
- Brown H, Spickett J (2014) Health consequence scales for use in health impact assessments of climate change. *Int J Environ Res Public Health* 11:9607–9620. <https://doi.org/10.3390/ijerph110909607>
- Brown H, Spickett J, Katscherian D (2014) A health impact assessment framework for assessing vulnerability and adaptation planning for climate change. *Int J Environ Res Public Health* 11:12896–12914. <https://doi.org/10.3390/ijerph111212896>
- Browne GR, Rutherford ID (2017) The case for “environment in all policies”: lessons from the “health in all policies” approach in

- public health. *Environ Health Perspect* 125:149–154. <https://doi.org/10.1289/EHP294>
- Buck LGM, Sundaram R (2012) Exposome: time for transformative research. *Stat Med* 31:2569–2575
- Campbell-Lendrum D, Corvalán C (2007) Climate change and developing-country cities: implications for environmental health and equity. *J Urban Health* 84:109–117. <https://doi.org/10.1007/s11524-007-9170-x>
- Center for Disease Control (2017) Healthy places—health impact assessment (HIA). <https://www.cdc.gov/healthypaces/hia.htm>. Accessed 14 Dec 2017
- Chiu WA, Euling SY, Scott CS, Subramaniam RP (2013) Approaches to advancing quantitative human health risk assessment of environmental chemicals in the post-genomic era. *Toxicol Appl Pharmacol* 271:309–323
- Clandinin DJ (2006) *Handbook of narrative inquiry: mapping a methodology*. SAGE Publications, Thousand Oaks
- Corburn J (2017) Urban place and health equity: critical issues and practices. *Int J Environ Res Public Health*. <https://doi.org/10.3390/ijerph14020117>
- Corburn J, Curl S, Arredondo G, Malagon J (2014) Health in all urban policy: city services through the prism of health. *J Urban Health* 91:623–636. <https://doi.org/10.1007/s11524-014-9886-3>
- Corvalan C, Hales S, McMichael AJ (Core Writing Team), Butler C et al (Extended writing team), Sarukhán J et al (Review editors) (2005) *Ecosystems and human well-being: health synthesis*. WHO, Geneva
- Cote I, Anastas PT, Birnbaum LS, Clark RM, Dix DJ, Edwards SW et al (2012) Advancing the next generation of health risk assessment. *Environ Health Perspect* 120:1499–1502. <https://doi.org/10.1289/ehp.1104870>
- de Blasio A, Girán J, Nagy Z (2012) Potentials of health impact assessment as a local health policy supporting tool. *Perspect Public Health* 132:216–220. <https://doi.org/10.1177/1757913910391039>
- de Leeuw E (2012) Do healthy cities work? A logic of method for assessing impact and outcome of healthy cities. *J Urban Health Bull N Y Acad Med* 89:217–231. <https://doi.org/10.1007/s11524-011-9617-y>
- de Leeuw E (2013) Evaluating WHO healthy cities in Europe: issues and perspectives. *J Urban Health Bull N Y Acad Med* 90:14–22. <https://doi.org/10.1007/s11524-012-9767-6>
- Dora C, Racioppi F (2003) Including health in transport policy agendas: the role of health impact assessment analyses and procedures in the European experience. *Bull World Health Organ* 81:399–403
- Fakhri A, Maleki M, Gohari M, Harris P (2014) Investigating underlying principles to guide health impact assessment. *Int J Health Policy Manag* 3:17–22. <https://doi.org/10.15171/ijhpm.2014.50>
- Farhang L, Bhatia R, Scully CC, Corburn J, Gaydos M, Malekafzali S (2008) Creating tools for healthy development: case study of San Francisco's Eastern Neighborhoods Community Health Impact Assessment. *J Public Health Manag Pract JPHMP* 14:255–265. <https://doi.org/10.1097/01.PHH.0000316484.72759.7b>
- Freudenberg N, Galea S (2008) Cities of consumption: the impact of corporate practices on the health of urban populations. *J Urban Health* 85(4):462–471
- Friel S, Hattersley E, Snowdon W, Thow A-M, Lobstein T (2013) Monitoring the impacts of trade agreements on food environments. *Obes Rev* 14(Suppl S1):120–134
- Gillingham MP, Halseth GR, Johnson CJ, Parkes MW (2016) *The integration imperative: cumulative environmental, community and health impacts of multiple natural resource developments*. Springer International Publishing AG, Cham
- Grant MJ, Booth A (2009) A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Inf Libr J* 26:91–108. <https://doi.org/10.1111/j.1471-1842.2009.00848.x>
- Green BN, Johnson CD, Adams A (2006) Writing narrative literature reviews for peer-reviewed journals: secrets of the trade. *J Chiropr Med* 5:101–117. [https://doi.org/10.1016/S0899-3467\(07\)60142-6](https://doi.org/10.1016/S0899-3467(07)60142-6)
- Haigh F, Harris E, Harris-Roxas B, Baum F, Dannenberg AL, Harris MF, Keleher H, Kemp L, Morgan R, Ng Chok H, Spickett J (2015) What makes health impact assessments successful? Factors contributing to effectiveness in Australia and New Zealand. *BMC Public Health* 15:1009. <https://doi.org/10.1186/s12889-015-2319-8>
- Hambling T, Weinstein P, Slaney D (2011) A review of frameworks for developing environmental health indicators for climate change and health. *Int J Environ Res Public Health* 8:2854–2875. <https://doi.org/10.3390/ijerph8072854>
- Hankivsky O, Cormier R (2011) Intersectionality and public policy: some lessons from existing models. *Polit Res Q* 64(1):217–229. <https://doi.org/10.1177/1065912910376385>
- Hankivsky O, Grace D, Hunting G, Giesbrecht M, Fridkin A, Rudrum S, Ferlatte O, Clark N (2014) An intersectionality-based policy analysis framework: critical reflections on a methodology for advancing equity. *Int J Equity Health*. <https://doi.org/10.1186/s12939-014-0119-x>
- Harris-Roxas B, Haigh F, Travaglia J, Kemp L (2014) Evaluating the impact of equity focused health impact assessment on health service planning: three case studies. *BMC Health Serv Res* 14:371. <https://doi.org/10.1186/1472-6963-14-371>
- Heller J, Givens ML, Yuen TK, Gould S, Benkhalti Jandu M, Bourcier E, Choi T (2014) Advancing efforts to achieve health equity: equity metrics for health impact assessment practice. *Int J Environ Res Public Health* 11:11054–11064. <https://doi.org/10.3390/ijerph111111054>
- Hickens MT, Gragg R, Hu H (2011) How cumulative risks warrant a shift in our approach to racial health disparities: the case of lead, stress, and hypertension. *Health Affair* 30:1895–1901
- Hirono K, Haigh F, Gleeson D, Harris P, Thow AM, Friel S (2016) Is health impact assessment useful in the context of trade negotiations? A case study of the Trans Pacific Partnership Agreement. *BMJ Open* 6:e010339. <https://doi.org/10.1136/bmjopen-2015-010339>
- Houghton A, English P (2014) An approach to developing local climate change environmental public health indicators, vulnerability assessments, and projections of future impacts. *J Environ Public Health*. <https://doi.org/10.1155/2014/132057>
- Ison E (2013) Health impact assessment in a network of European Cities. *J Urban Health Bull N Y Acad Med* 90:105–115. <https://doi.org/10.1007/s11524-011-9644-8>
- James P, Ito K, Buonocore JJ, Levy JI, Arcaya MC (2014) A health impact assessment of proposed public transportation service cuts and fare increases in Boston, Massachusetts (U.S.A.). *Int J Environ Res Public Health* 11:8010–8024. <https://doi.org/10.3390/ijerph110808010>
- Johnson Thornton RL, Greiner A, Fichtenberg CM et al (2013) Achieving a healthy zoning policy in Baltimore: results of a health impact assessment of the Transform Baltimore Zoning Code Rewrite. *Public Health Rep* 128:87–103
- Juarez PD, Matthews-Juarez P, Hood DB, Im W, Levine RS, Kilbourne BJ, Langston MA, Al-Hamdan MZ, Crosson WL, Estes MG, Estes SM, Agboto VK, Robinson P, Wilson S, Lichtveld MY (2014) The public health exposome: a population-based, exposure science approach to health disparities research. *Int J Environ Res Public Health* 11:12866–12895. <https://doi.org/10.3390/ijerph111212866>

- Kawachi I, Subramanian SV, Almeida-Filho N (2002) A glossary for health inequalities. *J Epidemiol Community Health* 56:647–652. <https://doi.org/10.1136/jech.56.9.647>
- Kjellstrom T, Friel S, Dixon J, Corvalan C, Rehfuess E, Campbell-Lendrum D, Gore F, Bartram J (2007) Urban environmental health hazards and health equity. *J Urban Health* 84:86–97. <https://doi.org/10.1007/s11524-007-9171-9>
- Korfmacher KS, Aviles K, Cummings BJ, Daniell W, Erdmann J, Garrison V (2015) Health impact assessment of urban waterway decisions. *Int J Environ Res Public Health* 12:300–321. <https://doi.org/10.3390/ijerph120100300>
- Krewski D, Westphal M, Andersen ME, Paoli GM, Chiu WA, Al-Zoughool M, Croteau MC, Burgoon LD, Cote I (2014) A framework for the next generation of risk science. *Environ Health Perspect* 122:796–805. <https://doi.org/10.1289/ehp.1307260>
- Kumaresan J, Prasad A, Alwan A, Ishikawa N (2010) Promoting health equity in cities through evidence-based action. *J Urban Health Bull N Y Acad Med* 87:727–732. <https://doi.org/10.1007/s11524-010-9500-2>
- Mahboubi P, Parkes MW, Chan HM (2015) Challenges and opportunities of integrating human health into the environmental assessment process: the Canadian experience contextualised to international efforts. *J Environ Assess Policy Manag* 17:1550034. <https://doi.org/10.1142/S1464333215500349>
- Mansfield TJ, MacDonald Gibson J (2015) Health impacts of increased physical activity from changes in transportation infrastructure: quantitative estimates for three communities. *Biomed Res Int*. <https://doi.org/10.1155/2015/812325>
- Marmot M (2007) Achieving health equity: from root causes to fair outcomes. *Lancet* 370:1153–1163. [https://doi.org/10.1016/S0140-6736\(07\)61385-3](https://doi.org/10.1016/S0140-6736(07)61385-3)
- Martenies SE, Wilkins D, Batterman SA (2015) Health impact metrics for air pollution management strategies. *Environ Int* 85:84–95. <https://doi.org/10.1016/j.envint.2015.08.013>
- Mathias KR, Harris-Roxas B (2009) Process and impact evaluation of the Greater Christchurch Urban Development Strategy Health Impact Assessment. *BMC Public Health* 9:97. <https://doi.org/10.1186/1471-2458-9-97>
- Monteiro C, Cannon G (2012) The impact of transnational “big food” companies on the South: a view from Brazil. *PLoS Med* 9:e1001252
- Mwatsama MK, Wong S, Ettehad D, Watt NF (2014) Global health impacts of policies: lessons from the UK. *Glob Health* 10:13. <https://doi.org/10.1186/1744-8603-10-13>
- Nadrian H, Nedjat S, Taghdisi MH, Shojaeizadeh D (2014) Urban traffic-related determinants of health questionnaire (UTDQH): an instrument developed for health impact assessments. *Med J Islam Repub Iran* 28:84
- Parkes MW (2012) Diversity, emergence, resilience: guides for a new generation of ecohealth research and practice. *EcoHealth* 8:137–139
- Parkes MW (2016) Cumulative determinants of health impacts in rural, remote, and resource-dependent communities. In: Gillingham PM, Halseth RG, Johnson JC, Parkes WM (eds) *The integration imperative: cumulative environmental, community and health effects of multiple natural resource developments*. Springer International Publishing, Cham, pp 117–149
- Pennington A, Dreaves H, Scott-Samuel A, Haigh F, Harrison A, Verma A, Pope D (2017) Development of an urban health impact assessment methodology: indicating the health equity impacts of urban policies. *J Public Health* 1:56–61. <https://doi.org/10.1093/eurpub/ckv114>
- Pies C, Barr M, Strouse C, Kotelchuck M, Team Best Babies Zone Initiative (2016) Growing a best babies zone: lessons learned from the pilot phase of a multi-sector, place-based initiative to reduce infant mortality. *Matern Child Health J* 20:968–973. <https://doi.org/10.1007/s10995-016-1969-1>
- Povall SL, Haigh FA, Abrahams D, Scott-Samuel A (2014) Health equity impact assessment. *Health Promot Int* 29:621–633. <https://doi.org/10.1093/heapro/dat012>
- Prochaska J, Kelley H, Linder S, Sexton K, Sullivan J, Nolen LB (2012) Health inequities in environmental justice communities: relevant indicators to reflect a variety of health threats. *Int J Equity Health* 11:A7. <https://doi.org/10.1186/1475-9276-11-S1-A7>
- Ross CL, Leone de Nie K, Dannenberg AL, Beck LF, Marcus MJ, Barringer J (2012) Health impact assessment of the Atlanta BeltLine. *Am J Prev Med* 42:203–213. <https://doi.org/10.1016/j.amepre.2011.10.019>
- Sartorius B (2013) Modeling determinants, impact, and space-time risk of age-specific mortality in rural South Africa: integrating methods to enhance policy relevance. *Glob Health Action* 6:19239. <https://doi.org/10.3402/gha.v6i0.19239>
- Schaff K, Desautels A, Flournoy R, Carson K, Drenick T, Fujii D, Lee A, Luginbuhl J, Mena M, Shrago A, Siegel A, Stahl R, Watkins-Tarrt K, Willow P, Witt S, Woloshin D, Yamashita B (2013) Addressing the social determinants of health through the Alameda County, California, place matters policy initiative. *Public Health Rep* 128:48–53
- Sen G, Iyer A, Mukherjee C (2009) A methodology to analyse the intersections of social inequalities in health. *J Hum Dev Capab* 10(3):397–415. <https://doi.org/10.1080/19452820903048894>
- Serrano E, Larranaga I, Morteruel M et al (2016) Urban regeneration as population health intervention: a health impact assessment in the Bay of Pasaia (Spain). *J Equity Health*. <https://doi.org/10.1186/s12939-016-0424-7>
- Sexton K, Linder SH (2010) The role of cumulative risk assessment in decisions about environmental justice. *Int J Environ Res Public Health* 7(11):4037–4049
- Sexton K, Linder SH (2011) Cumulative risk assessment for combined health effects from chemical and nonchemical stressors. *Am J Public Health* 101(1):S81–S88
- Shankardass K, Renahy E, Muntaner C, O’Campo P (2015) Strengthening the implementation of health in all policies: a methodology for realist explanatory case studies. *Health Policy Plan* 30:462–473. <https://doi.org/10.1093/heapol/czu021>
- Simos J, Spanswick L, Palmer N, Christie D (2015) The role of health impact assessment in Phase V of the Healthy Cities European Network. *Health Promot Int* 30:i71–i85. <https://doi.org/10.1093/heapro/dav032>
- Spickett JT, Brown HL, Katscherian D (2011) Adaptation strategies for health impacts of climate change in Western Australia: application of a health impact assessment framework. *Environ Impact Assess Rev* 31:297–300. <https://doi.org/10.1016/j.eiar.2010.07.001>
- Stuckler D, McKee M, Ebrahim S, Basu S (2012) Manufacturing epidemics: the role of global producers in increased consumption of unhealthy commodities including processed foods, alcohol, and tobacco. *PLoS Med* 9(6):e1001235
- Tuomisto JT, Niittynen M, Pärjälä E, Asikainen A, Perez L, Trüeb S, Jantunen M, Künzli N, Sabel CE (2015) Building-related health impacts in European and Chinese cities: a scalable assessment method. *Environ Health* 14:93. <https://doi.org/10.1186/s12940-015-0082-z>
- Weiss D, Lillefjell M, Magnus E (2016) Facilitators for the development and implementation of health promoting policy and programs—a scoping review at the local community level. *BMC Public Health* 16:140. <https://doi.org/10.1186/s12889-016-2811-9>
- WHO (2007) The health impact assessment procedure. <http://www.who.int/hia/tools/process/en/>. Accessed 1 Dec 2017

- Wier M, Sciammas C, Seto E et al (2009) Health, traffic, and environmental justice: collaborative research and community action in San Francisco, California. *Am J Public Health* 99:S499–S504. <https://doi.org/10.2105/AJPH.2008.148916>
- Wild CP (2012) The exposome: from concept to utility. *Int J Epidemiol* 41:24–32
- Wiles R, Crow G, Pain H (2011) Innovation in qualitative research methods: a narrative review. *Qualitative Research* 11:587–604. <https://doi.org/10.1177/1468794111413227>
- Winkler MS, Utzinger J (2014) The search for underlying principles of health impact assessment: progress and prospects. *Int J Health Policy Manag* 3:107–109. <https://doi.org/10.15171/ijhpm.2014.69>
- Wise M, Harris P, Harris-Roxas B, Harris E (2009) The role of health impact assessment in promoting population health and health equity. *J Aust* 20:172–179
- Yuen TK, Payne-Sturges DC (2013) Using health impact assessment to integrate environmental justice into federal environmental regulatory analysis. *New Solut* 23:439–466