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Review

A Framework for Developing Environmental Justice Indicators

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Abstract: Environmental justice (EJ) is a broad discipline that attempts to understand and redress unfair exposure to unhealthy environmental conditions. EJ is often made measurable with indicators, however the capabilities and the limitations of EJ indicators can be difficult for policy makers to understand. Using an exploratory review of EJ literature, this paper performs a research translation role by clarifying the key terms used to describe EJ indicators and by providing conceptual frameworks for developing locally valid EJ indicators for government and community. Issues such as the position of EJ in the context of the social determinants of health, indicator development, and definitions are explored. The exploratory literature review highlighted the potential and limitations of EJ indicators for measuring the extent and impact of EJ issues on human health and the environment. We found that EJ indicators are invariably (1) composed of two or more measures, and (2) developed iteratively, in consultation with those affected. To aid governments and communities, we present both a top-down and a bottom-up framework for developing EJ indicators, with the bottom-up framework guiding the combination of measures from four different core elements; environment, demography, epidemiology and procedures. A list of evidence-based example measures, from the literature, for developing EJ indicators is also provided. It is anticipated that the frameworks and list of EJ example measures will provide guidance for efficiently developing locally relevant EJ indicators.

Keywords: environmental justice; indicators; social determinants of health; distributional justice; correlational epidemiology; procedural justice; restorative justice; lead and lag; validity; reliability

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1. Introduction

The discipline of environmental justice (EJ) focusses on the distribution of environmental 'bads'—particularly pollution—because of their harmful effects on human health. The discipline has long recognised that inequities in exposure to pollution are avoidable and has called on governments and agencies to redress inequities through policy and planning. However, this focus of EJ is changing with growing understanding that it is the full scope of conditions in humans' environments that affects health [1]. A broader and arguably more holistic definition of EJ uses the same approach to understand and redress inequities in urban issues that, while outside the terms of reference of environmental protection agencies, are nevertheless within the capacity of governments to address [2–4].

Inherent in definitions of EJ are two core components: environments and people. However, within this broad scope is a wide range of terminology and concepts for understanding how exposure to different harmful environments impacts health. For example, within the EJ literature, the term justice is usually used to mean equity (c.f. [5]), giving most EJ literature an ethical, rather than a legal framing. Despite this, broader definitions of EJ do include the extent of voice and protection afforded to minority groups through legal and political systems and this is known as *procedural justice* [6–9]. Consistent with its broad scope, other sub-disciplines of EJ are *distributional justice*, *correlational epidemiology*, and *restorative justice*, the last of which is itself a relatively narrow sub-discipline of *procedural justice* that deals with the redress of illegal or unethical inequalities in exposure to

pollution [10]. Each one draws upon different kinds of evidence to understand a facet of EJ so that policies or government agencies can respond accordingly. Despite their importance, these terms are not always defined.

Environmental justice is often measured with indicators. An indicator is a phenomenon of community concern defined to a point where it is quantifiable and measurable [11]. In this paper, 'measure' is used to denote a single dataset, that could be objective or subjective, whereas 'indicators' are "signs or signals that relay a complex message, from potentially numerous sources (or measures), in a simple and useful manner" (p. 49, [12]). In environment and public health planning, an indicator typically quantifies an issue of concern in a simplified way, tracks its change over time, and is used to inform decision-making [13]. In essence, EJ indicators move EJ issues from the abstract to the specific and quantifiable. However, even when using indicators, some terminology is often used without complete explanation, as is the case with lead and lag indicators, which represent either forward looking or historical information [11,12].

Indicators are often used in health planning to prioritise issues for action, to evaluate the success of policy and, less appropriately (because they do not, in isolation, show what works [14,15]), to decide what to do to improve health or equity [13,16]. In contrast with indicators from other fields which often contain only one measure, an EJ indicator must, by definition, incorporate measures from two or more fields; most commonly, one or more demographic measures, usually as the independent variable, analysed against a measure of environmental condition as the dependent variable [17]. Indeed, in most cases, it is only by combining measures in this way that indicators capable of detecting existing or potential environmental injustice are created. Consequentially, while the term *environmental justice* is widely used, it is invariably defined and measured using locally specific indicators made up of context-specific measures (which may be objective or subjective) that are especially designed to answer an EJ question of interest to a specific community.

Aims

The discipline and terminologies of EJ are multifaceted. Similarly, while there is very well-developed scientific literature that uses EJ indicators, the potential of indicators; their power but also their limitations, can be challenging for government decision-makers and communities to understand. The aim of this paper is twofold. First, to consolidate what is known about EJ indicators to create clarity for those who wish to use them to inform decision making for improved health equity. Secondly, to conceptually and practically advance the use of EJ indicators through the use of frameworks for their creation. Specifically, in this paper we aim to:

1. Place EJ within the broader social determinants of health model;
2. Provide definitions of distributive justice, correlational epidemiology, procedural justice, restorative justice, and lead and lag indicators;
3. Provide guidance on methods for moving environmental justice from the theoretical to the measurable using frameworks that assist local governments, state government agencies and community groups to construct locally valid indicators; and
4. Provide a list of example measures from EJ and other literature that can be used to design locally valid indicators of environmental justice.

2. Definitions and Scope of Environmental Justice

In this section, three important aspects of EJ indicators are covered. The first of these is the conceptual convergence of EJ into an understanding of the broader social determinants of health and the opportunities for health equity that this presents. The second is an exploration of the sub-disciplines of EJ, and the roles that indicators of various types can play in improving health equity. The third is explanations of lead and lag indicators and of their potential in decision making intended to improve health equity.

2.1. Environmental Justice within a Broader Understanding of Social Determinants

Health is determined by the entire ecology of the places we live; the natural, built, social and economic environments in which we are born, live, learn, work, play and age [1,18]. This is exemplified by studies showing that a person's post code is a powerful predictor of their health [19]. The environments in which we live are the *upstream* causes of health [20], with poorer conditions coinciding with and exacerbating poorer health [21]. *Big data* from epidemiology and demographics have increased certainty about the relationships between environment and health [22]. They show that, while the relationships are complex [23], at the population level, health exhibits a social gradient: people who have more resources live in the most health promoting environments, which results in better health outcomes [24–28]. The social gradient is illustrated at the global scale by the *Preston Curve.* It shows that on average, individuals born in richer countries live longer than those born in poorer countries [29]. Illustrating this, urbanisation means that increasingly, human ecologies are designed and built [30,31], but in ways that result in inequitable distributions of health-giving or *salutogenic* environments [21,32] that contain for example, public open space, healthy food and affordable housing [2]. Marmot and Bell state that such inequities are avoidable because they "are the result of political choice" (p. 1171, [33]). These ideas are encapsulated in what has become known as *the social determinants of health (SDH)* model [18,28], adeptly illustrated by Dahlgren and Whitehead [1]. The literature includes several SDH frameworks, including The Commission for Social Determinants of Health's *conceptual framework* that covers the entire human ecology [34], and Barton and Grant's [35] Health Map for the Local Human Habitat that focuses specifically on the built environment.

In recent years, *liveability* has arisen as an ideal for which cities should strive and is used for city promotion on the international stage [36]. Yet definitions of liveability are inconsistent. Some emphasize city image and global economic competitiveness and others, determinants of health equity [37]. To bring some clarity to *liveability* as well as a social justice perspective that is missing from many conceptualizations of the term, Lowe et al. examined how it has been defined and measured in peer reviewed literature. They found that a liveable place, irrespective of its global location, is one that is,

safe, attractive, socially cohesive and inclusive, and environmentally sustainable; with affordable and diverse housing linked by convenient public transport, walking and cycling infrastructure to employment, education, public open space, local shops, health and community services, and leisure and cultural opportunities [38].

The qualities of liveability in this evidence-based definition are consistent with the social determinants of health model. They can be used as an important part of the definition of environmental justice, one that is supported by the broader literature and that extends beyond exposure to pollution—or negative environmental conditions—to include opportunities to be healthy provided by the built environment; positive environmental conditions. Including indicators of liveability in the broader discipline of EJ is a way of acknowledging that it is not just pollution, but humans' entire ecology [34], that determines their health [39]. Figure 1 shows how such issues (usually framed positively) can complement traditional, negative pollution-related EJ issues to facilitate the creation of a more holistic definition of EJ. The majority of EJ issues, because they are socially determined, could be redressed by political and/or policy decisions. Environmental injustice is therefore very much avoidable [33].

As is the case for the more traditional EJ indicators, poor liveability—measured with indicators such as those described above—generally correlates with certain demographics. For example, minority groups that are already disadvantaged are more likely to live in areas with environmental bads, amplifying existing disadvantage [23]. Liveability also interacts with negative issues such as pollution in complex ways with quality built environments compensating, to an extent, for pollution's negative impacts on health [40]. For example, walkable inner-city areas can have poor air quality associated with increased traffic compared to outer areas that are less walkable but have better air quality [41].

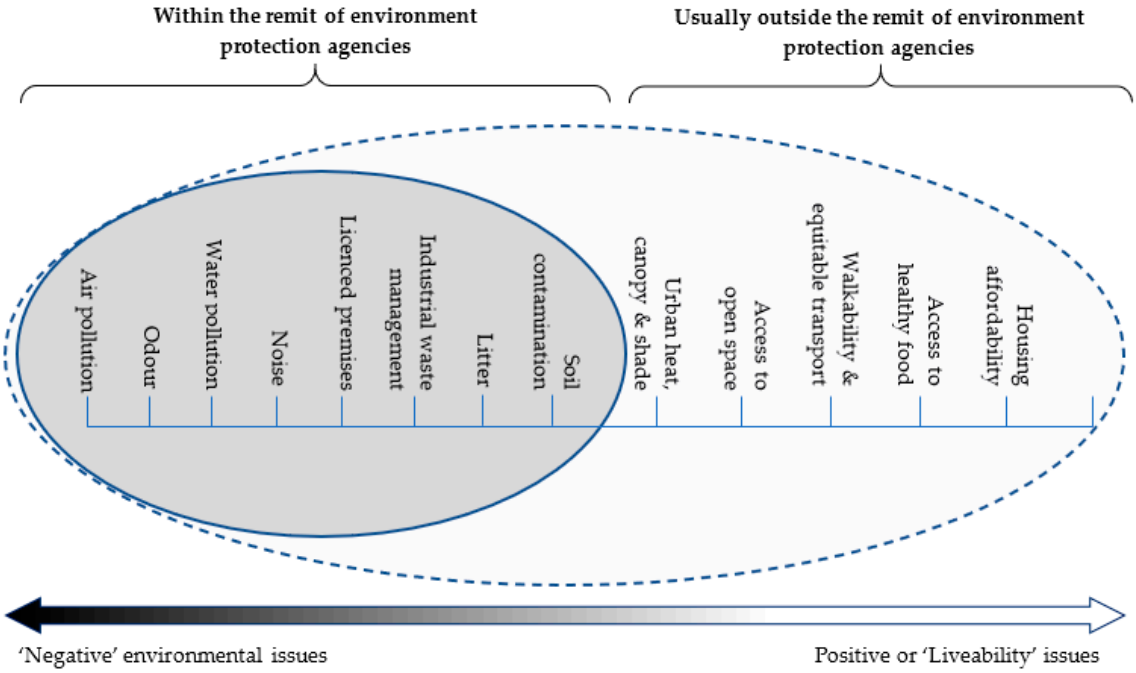

Figure 1. Environmental justice issues occur on a continuum and can be thought of as negative, e.g., pollution-related (to the left), or more positive, e.g., issues associated with liveability (to the right).

Despite a clear link between EJ and liveability, the social determinants model is not often explicitly acknowledged in empirical EJ literature, or if it is, *social determinants* is sometimes considered to be a separate concept see [42]. This may be due to EJ originating in the civil rights and environment movements [43], whereas the concept of social determinants has evolved out of 'the new public health' [18,44]. Another possible explanation is that EJ campaigns are often conducted in response to quite local issues, with empirical EJ studies generally examining inequitable exposure of specific communities at the low end of the social gradient and to one or two negative factors [2,3]. In contrast, the social determinants model considers such issues in the context of the whole raft of factors that inevitably affect populations differentially. Despite the public health and environment/civil rights movements apparent siloing, the links between them should be emphasised in situations when doing so can improve communication between practitioners that is important for creating healthier environments.

2.2. Key Definitions in Environmental Justice

Several different terms, that denote or often align with sub-disciplines within EJ, are used in the literature. Understanding the meaning of these terms, and how the concepts therein relate to each other and the broader discipline of EJ is foundational for understanding the multi-dimensionality of EJ issues, for making best use of the potential of indicators, and for developing appropriate policy responses. Chief among the terms are *distributional justice*, *correlational epidemiology*, *procedural justice* and *restorative justice*. The terms *lead* and *lag*, with reference to indicators, are also used. The following sections define these terms.

2.3. Terms That Denote Sub-Disciplines within EJ

Distributive injustice is the social patterning of unfair and avoidable exposure to industrial pollutants [45] and arguably stands at the core of the EJ discipline. Studies of distributional environmental justice generally use lead indicators, i.e., those that identify inequitable risk before poor health manifests, to look at the relationship between socioeconomic status (as independent variables) and pollutant levels (as dependent variables). In the literature, most indicators of environmental justice do this by analysing demographic

and environmental data together at a range of spatial scales to detect inequitable exposure to pollution or inadequate access to healthy environments.

The literature on *distributive injustice* covers diverse environment issues such as contaminated sites [46], noise [47], diffuse/ambient air pollutants [48], soil contamination [49], contaminated drinking water [50], hydrocarbon extraction or *fracking* (c.f. [51,52]), and floods [53]. As indicated above, *distributive justice* is also used in reference to access to housing [54] and other liveability issues, such as green open space [55,56], and beach access for recreational use [57], demonstrating that the concept is equally applicable to both environmental bads (such as pollution) and goods or salutogenic /liveable environments [58].

A wide range of demographic measures is used to characterise disadvantage (See Supplementary Materials for examples). Examples are age [59], education [60], gender [61], employment [62], economic resources [63], household income [60], English proficiency [17], Indigeneity [64], racial characteristics [50], students' eligibility for free meals [65] (US), marital status [66], indices of relative disadvantage [67] and multi-factor deprivation indices [68]. Occasionally behavioural epidemiology such as smoking or alcohol consumption is used as a proxy for disadvantage [69].

Various geographic scales are used in *distributive injustice* indicators. They include SA1, SA2 (≈400 and ≈10,000 persons, respectively (Australia) [70]) Census block (0–≈400 people) and Census block group (≈600 to ≈3000 people) [71], school location [47], playground location [49], community water system area [50], a 200-metre grid (France) [72], and Intermediate geography zone (IGZ; ≈2500–≈6000 people) [73] or local authority district (LAD; ≈2,300–≈1.1 million people; UK) [66]. In general, studies show that people with more exposure to industrial pollution have lower socio-economic status. Strictly speaking, indicators of *distributive injustice* do not include measures of health. This can be because epidemiological data that are relevant to environmental equity issues are difficult to obtain cf. [7]. Where epidemiological data are available, combining them with demographic and environmental data evolves the indicator beyond one of simple distributive justice. This specializes the indicator, making it more powerful for examining the site or problem under investigation, since it relates to both the environment and the health of the people being affected by the pollution or EJ issue.

A second sub-discipline of EJ, referred to here as *correlational epidemiology*, is the identification of relationships between land uses and health. Studies of correlational epidemiology generally use lag indicators, i.e., those that identify reduced health and wellbeing in communities attributed to pollution, to identify whether there is a relationship (a *spatial coincidence* [2]) between land uses, particularly those assumed (or understood, from other studies) to be a health risk and indicators of health. These studies measure pollutants or refer to existing evidence to infer risk (e.g., 'coalfield communities' [66]). EJ indicators of this type use land-use, e.g., the location of industrial facilities, as independent variables and the incidence of disease as the dependent variable. They can sensitise decision-makers to likely equity issues, but, as with distributional justice, inequities in health can be further teased out when an additional element, in this case demography, is also factored in.

A third type, *procedural (environmental) justice*, describes processes [58], especially equitable access and use of procedures for preventing or redressing distributive injustices. Maantay [5] states that indicators of procedural justice also have the capacity to build organisational reputation through transparent disclosure and accountability. Issues of *procedural justice* include disparities (e.g., between demographic groups) in the inspection rates of potentially polluting facilities or in the enforcement of environmental regulations [46,74]. A further subset of procedural EJ is *restorative* or *corrective justice*, which Kuehn describes as actions that seek to redress illegal or unethical inequalities in, for example, exposure to pollution [10]. Studies of procedural EJ generally look at whether processes such as emission standards (and their enforcement), inspection regimes, timeliness of response to complaints and community consultation are provided equitably (see for example [75,76]). Consistent with the principle that "what we measure affects what we do" (p. 7, [77]), indicators of procedural justice have the capacity to attune policymakers to inadequacies in, for example,

fair investment into EJ issues, provided a demographic measure is included. For example, the simple (non EJ) indicator, 'time to respond to community-reported pollution complaints' does not measure procedural EJ because it includes no information about demographic differences [78,79].

Most of the empirical EJ literature falls into the category of *distributional environmental justice* and such studies are often published in scientific journals. However, Todd and Zografos [80] state that community environmental activists give greater weight to *procedural environmental justice* because the community is generally more interested in the redress of known injustices (or *restorative justice*) than it is in identifying existing injustice. Articles on *procedural justice* are typically found in social science and legal journals and tend to be more qualitative in their methods and approach.

2.4. Lead and Lag Indicators

Environmental justice indicators can also be broadly divided into *lead* and *lag* indicators. *Lead indicators* differentiate early warning indicators of inequitable risk before poor health manifests from *lag indicators* that detect health inequities that have occurred as a result of inequitable exposure to pollution or unhealthy built environments. The terms are not commonly used in the EJ literature but can nevertheless be useful for communicating, with professionals from industrial health and safety and business—disciplines which use the terms often [81,82]—indicators' temporal relationships with each other and with the issue under investigation. In EJ, *lead indicators* often measure distributive justice. Examples of environmental measures in lead indicators are the location of polluting industries [17] and plume sites [83], releases of toxic chemicals [84], noise [85], soil contamination [73], nitrite levels in drinking water [50], location of coalfields (UK) [66] and diffuse air pollution [65] (See Supplementary Materials).

Liveability measures such as social, economic and built environment factors can also be used to create effective lead indicators. They have the capacity to alert decision-makers about the areas of a city that provide fewer opportunities to be healthy, before poor health manifests. In contrast, *lag indicators* identify reduced health and wellbeing in communities, usually as a result of pollution. Additionally, with the inclusion of liveability in EJ, issues such as chronic disease linked to, for example, poor walkability could also be considered lag indicators. Thus, lag EJ indicators include measures of epidemiology, demographics and occasionally, exposure [86,87] and example epidemiology measures in lag indicators are cancer incidence (US) [88], mortality (Australia) [89] and respiratory cases (UK) [73].

3. Developing Indicators; Top Down or Bottom Up

The most valid (i.e., relevant and useful, defined below) and effective indicators are developed consultatively and are relevant to community partners. The involvement of those who are closest to the issue, will be collecting data, and/or using the indicators to inform decision-making, is vital. The word *selection* is frequently used in regard to indicators (for example, in *indicator selection criteria* [90,91]). However, indicator *selection* can be misleading as it implies that a valid indicator can be easily chosen from a pre-existing list of candidate indicators. While there are certainly many measures that are common to environment indicators, there is a low likelihood that a fully formed indicator, selected from a repertoire of indicators, would be sufficiently valid for understanding a local issue. This is even more the case for an EJ indicator which must necessarily incorporate two or more context- and issue-relevant measures (most commonly a demographic measure and an environmental measure) if it is to successfully elicit useful information about an issue. Therefore, rather than *selecting* an indicator, it is perhaps more accurate to think in terms of *creating* an indicator. Consistent with this distinction, the creation of environmental justice indicators can be thought of in two ways; *top-down* and *bottom-up*. While the frameworks are presented separately, they are not exclusive: ways of thinking from both can be used to inform each occasion that EJ indicators need to be developed. The frameworks are detailed below.

3.1. Top-Down: From Concepts, to Issues, to Indicators

A *top-down* approach to the development of EJ indicators occurs when *environmental justice* is successively defined to the point where it becomes measurable. The top-down approach is useful for ensuring that all possible issues of environmental injustice are detected and may be of interest to a local government or an environmental protection agency that needs to establish and demonstrate that it has oversight of EJ issues in its jurisdiction and is monitoring them. Figure 2 illustrates how a hypothetical indicator might be developed using an increasingly focused, top-down approach, moving from the broad and loosely defined concept, into something specific and measurable. The figure illustrates this with the example of coal seam gas (CSG) extraction; or *fracking*, as it affects Aboriginal Australians. The figure also shows that other divergent refinements can be thought of as branching off to result in indicators that measure quite different aspects of EJ.

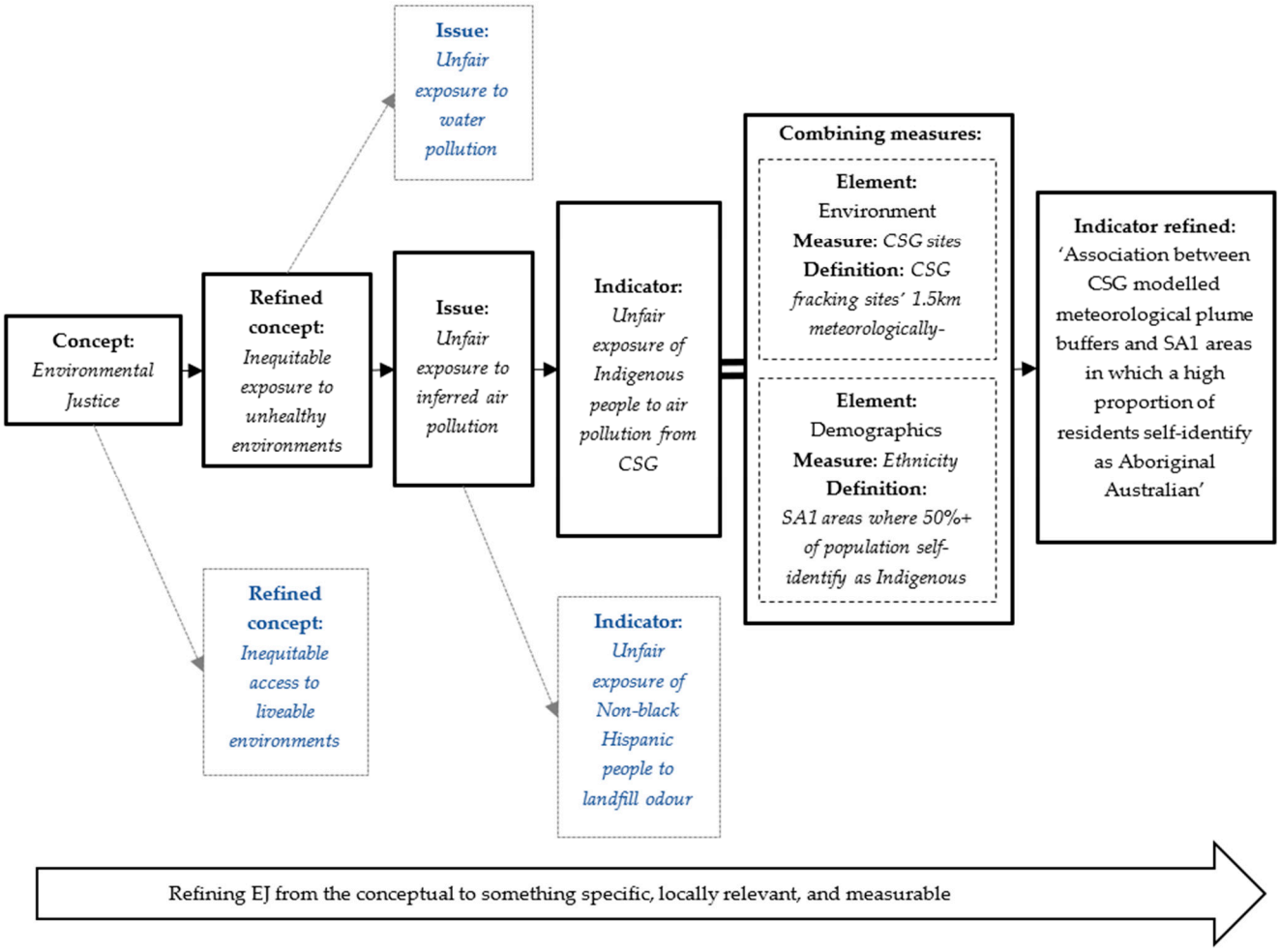

Figure 2. A hypothetical example of how the concept *environmental justice* is moved from the abstract to a locally specific and measurable indicator.

When developing indicators using a top-down approach, careful consideration of data availability, and of the cost implications of sustained monitoring are needed. The approach demonstrates that conceptual refinement (rather than *selection*) is likely to provide the most useful indicators. Nevertheless, when moving from the broad to the specific, useful indicators can often be created using existing datasets combined in new ways. In other cases, datasets capable of quantifying the elements of interest may not exist, and so new data collection protocols and monitoring programs will need to be established.

3.2. Bottom-Up: A Framework for Environmental Justice Indicators

A top-down approach might be useful for surveilling (e.g., by a government monitoring agency) a region for possible environmental injustices. However, the diversity of EJ indicators used in the literature suggests that it is more common, and practical, for indicators to be developed from the bottom-up, in response to known or suspected issues, and to answer the questions of specific audiences. In a bottom-up approach, a consultative process of problem definition to determine the exact nature of the issue of concern [92], and therefore which measures should be combined to form the indicator, is used. Thus, a context driven, locally relevant expression of EJ is created. This requires careful consideration of the nature of the issue itself (i.e., problem definition), of existing and new data sources, and of analysis capabilities.

To facilitate the bottom-up approach, Figure 3 shows how constituent measures can be grouped into a theoretical framework of four broad elements. Consistent with the OECD (2008) regarding theoretical frameworks, Figure 3 shows that the elements can be combined to create environmental justice indicators for different purposes. In the upper left, the framework includes both harmful (e.g., pollution) and salutogenic (e.g., liveability) issues under the core element, *Environment*. The framework is also founded in the idea that an understanding of equity, enabled through demography, is foundational to the issue of environmental justice, and places *Demographic* measures lower left. Next, because the health of communities is important for understanding many (but not all) environmental justice issues, *Epidemiology* is included upper right. Finally, *Procedures* are included lower right because they are important for creating indicators capable of measuring procedural justice (See Figure 3). Alongside the framework, the Supplementary Materials lists measures from the literature that have been used to define and quantify the elements. The framework can thus be thought of as a recipe for creating useful environmental justice indicators, while the example measures are a small selection of possible ingredients. The framework emphasises that the most locally valid EJ indicators will be created by combining existing, or newly created measures, rather than *selected*. Several examples are given, and for each, component measures are or could be drawn from existing literature that appear in the Supplementary Materials. Four of the examples—shaded green in Figure 3—are explored in more detail.

Example indicator 1, 'Variation in exposure to air pollution by SES', a lead indicator, can be created by analysing, for example, socio-economic status using the *Index of Relative Socio-economic Disadvantage* at SA1 level [93] as the independent variable, against an air pollution measure such as 24h average $PM_{2.5}$ concentrations [94]. Similarly, Indicator 2; 'Asthma cases by proximity to licensed facilities', a lag indicator, can be created by analysing, for example, 1.0 km radial buffer around EPA-licensed polluting sites [17] as the independent variable against hospitalization rates per 10,000 residents using hospital discharge data [95] as the dependent variable.

A third example, Indicator 3, combines three measures: asthma from *Epidemiology*, low socio-economic status from *Demographics* and locations of licensed facilities from *Environment*. It is a composite indicator that can identify who is affected and also draw some inferences about why. Composite indicators such as this, especially when they are monitored over time, have the capacity to build evidence and refine knowledge about a specific site-related issue. They can thus move beyond simple correlation to demonstrate causality, where it exists. A fourth example (Indicator 4) is another composite indicator. It would combine data from each of the *Environment*, *Demography* and *Procedures* elements to map the location of facilities for which license breaches were successfully prosecuted, against the socio-economic status of the surrounding area. Such an indicator can detect whether there is equitable provision of legal services to all sectors of the community, or whether service provision favours those who are well-resourced and thus better able to advocate on their own behalf [96]. More refined indicators such as this (i.e., created by analysing three or more datasets together) have the capacity to answer uniquely local EJ questions.

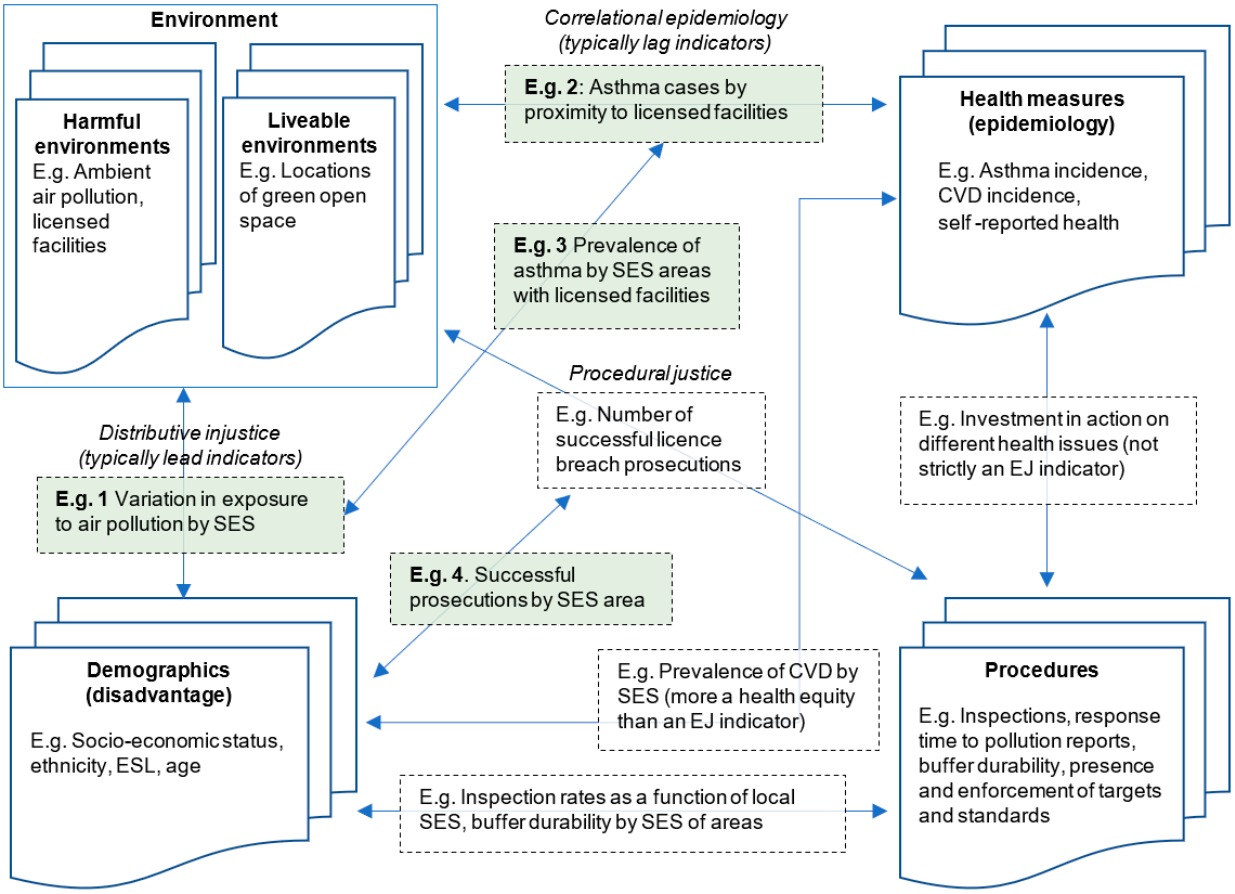

Figure 3. The EJ indicator framework showing the four core elements of EJ. Examples of the ways that the literature has defined each of the four aspects can be found in Supplementary Materials. Some example indicators are shown in dashed-bordered boxes.

3.3. Principles for Building and Using Indicators and Indicator Suites

As with all indicators, to be most useful, EJ indicators must be designed with thought and consultation regarding the knowledge that needs to be created [97]. Both subjective and objective measures may be combined with the resulting indicators of each type thought of as complementary rather than congruent. Regardless of the constituent measures, the analyses that are conducted, or how the data are displayed, it is essential that indicators fulfil their intended purpose and that they use best practice techniques to provide useful information about the issue of concern.

At the most basic level, the data for an indicator must be reliable. This is a relatively straightforward quality meaning that an indicator's constituent measures, regardless of the elements under investigation, must have been constructed using consistent and trustworthy data collection methods [98]. Frequent and longitudinal data collection are essential for EJ indicators. Sustained monitoring using reliable methods at a frequency capable of creating longitudinal data that can detect changes as a result of policy is essential. Additionally, indicators must be valid, meaning they must accurately describe the phenomenon of interest. Validity is a multifaceted quality because that is unique for each indicator. The following qualities, derived from Davern, Gunn [15], and Niemeijer and de Groot [90] are a summary of best practice principles for helping to ensure validity when either selecting existing candidate indicators or designing new ones. Firstly, indicators should measure what they are intended to measure (*construct validity*). This means that clarity about the issue of concern should be created with all stakeholders. Going through the process of refining the issue with stakeholders, e.g., using Figure 3, can assist with this and will also help ensure that the indicator is policy-relevant; able to both inform decision-making and

to detect the effects of policy change. The indicator should also fully represent what it aims to measure (or *content validity*). That is, the indicator should be sensitive to change and be able to detect trends over time. Indicators should also be widely understood, correspond to lived reality and should engage the public, e.g., in their design, monitoring and in policy responses (or *face validity*) [99].

For increased accessibility, the information that indicators elicit should be displayed using appropriate data visualisation (e.g., mapping, charts, or simple infographics such as traffic light systems [5,100,101]). Finally, the power of indicators can be increased when they are used in suites, provided that the indicators therein are complementary, rather than overlapping which unnecessarily increases the monitoring burden.

In addition to the values of reliability, validity and complementarity which are indicator specific, environment protection agencies should monitor sites and industries known to be hyper-polluters, or 'the worst of the worst' [102] in terms of pollution. Likewise, environment monitoring should focus on areas of known low socio-economic status as this is a powerful proxy indicator of reduced health and wellbeing due to both negative (e.g., pollution) and absence of positive (i.e., liveability) factors.

4. Conclusions

Globally, significant inequities remain in both exposure to pollution and in access to environments that support health. With evidence suggesting that health equity is at least as important for an efficient and stable society as is a high average level of health [103,104], preventing unequal health outcomes attributable to pollution and poor liveability is vital. A range of indicators about *distributive injustice, correlational epidemiology, procedural justice* from within the broad discipline of EJ is essential for eliciting different information, detecting the presence of, and enabling a nuanced understanding of EJ issues. However, the capabilities of EJ indicators of various types are not always well-understood, nor are the terms used in the EJ literature always defined. This paper has aimed to define these terms and to offer guidance on the development of suitably valid and reliable indicators of environmental justice.

The paper has shown that useful EJ indicators are invariably made up of at least two measures from a combination of the environment, demography, epidemiology or procedures elements. Furthermore, the way that measures are combined determines the type of EJ indicator that is created, enabling different facets of an issue to be understood.

These foundational principles were then applied in frameworks exploring both the top-down and bottom-up creation of EJ indicators. Alongside the frameworks, example measures (in Supplementary Materials) show the range of ways that the literature has defined and measured the four elements, constituting a short list of possible measures that might be recombined to create new, locally valid indicators.

It is hoped that the frameworks will build indicator literacy amongst those working in the EJ space, including environment protection agencies, local governments and community groups, so that they can quickly develop locally valid indicators for detecting environmental injustices, a first step in redressing such injustices and for creating greater health equity.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/standards2010008/s1, Table S1: Elements and example measures for building environmental justice indicators. References [17,47,48,50,51,59–65,67–69,73,74,83–85,88,89,93–95,105–157] are cited in the supplementary materials.

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References

1. Göran, D.; Whitehead, M. *Policies and Strategies to Promote Equity in Health*; Regional Office for Europe, Ed.; Institute for Futures Studies: Stockholm, Sweden, 1991.
2. Chakraborty, J.; Maantay, J.A.; Brender, J.D. Disproportionate Proximity to Environmental Health Hazards: Methods, Models, and Measurement. *Am. J. Public Health* **2011**, *101*, S27–S36. [CrossRef] [PubMed]
3. EOEEA. Environmental Justice Communities in Massachusetts. Environmental Justice. 2019. Available online: https://www.mass.gov/info-details/environmental-justice-communities-in-massachusetts (accessed on 26 June 2019).
4. US Environmental Protection Agency. Environmental Justice. 2019. Available online: https://www.epa.gov/environmentaljustice (accessed on 20 March 2019).
5. Maantay, J. Mapping environmental injustices: Pitfalls and potential of geographic information systems in assessing environmental health and equity. *Environ. Health Perspect.* **2002**, *110*, 161–171. [CrossRef] [PubMed]
6. Bullard, R.D. *Dumping in Dixie: Race, Class, and Environmental Quality*; Westview Press: Boulder, CO, USA, 1990.
7. Maantay, J. Asthma and air pollution in the Bronx: Methodological and data considerations in using GIS for environmental justice and health research. *Health Place* **2007**, *13*, 32–56. [CrossRef] [PubMed]
8. Mohai, P.; Pellow, D.; Roberts, J.T. Environmental Justice. *Annu. Rev. Environ. Resour.* **2009**, *29*, 405–430. [CrossRef]
9. Schlosberg, D.; Carruthers, D. Indigenous Struggles, Environmental Justice, and Community Capabilities. *Glob. Environ. Politics* **2010**, *10*, 12–35. [CrossRef]
10. Kuehn, R.R. A taxonomy of environmental justice. *Environ. Law Rep.* **2000**, *3*, 10681.
11. Berger, P.; Luckmann, T. *The Social Construction of Reality*; Allen Lane: London, UK, 1967.
12. Kurtz, J.C.; Jackson, L.E.; Fisher, W.S. Strategies for evaluating indicators based on guidelines from the Environmental Protection Agency's Office of Research and Development. *Ecol. Indic.* **2001**, *1*, 49–60. [CrossRef]
13. Scott, K. *Measuring Wellbeing: Towards Sustainability?* Routledge: London, UK, 2012.
14. Armstrong, R.; Waters, E.; Dobbins, M.; Anderson, L.; Moore, L.; Petticrew, M.; Clark, R.; Pettman, T.L.; Burns, C.; Moodie, M.; et al. Knowledge translation strategies to improve the use of evidence in public health decision making in local government: Intervention design and implementation plan. *Implement. Sci.* **2013**, *8*, 121. [CrossRef]
15. Davern, M.T.; Gunn, L.; Giles-Corti, B.; David, S. Best Practice Principles for Community Indicator Systems and a Case Study Analysis: How Community Indicators Victoria is Creating Impact and Bridging Policy, Practice and Research. *Soc. Indic. Res.* **2016**, *131*, 567–586. [CrossRef]

16. Innes, J.E. *Knowledge and Public Policy: The Search for Meaningful Indicators*, 2nd ed.; Transaction Publishers: New Brunswick, NJ, USA, 1990.
17. Gunn, L.D.; Greenham, B.; Davern, M.; Mavoa, S.; Taylor, E.J.; Bannister, M. Environmental Justice in Australia: Measuring the Relationship Between Industrial Odour Exposure and Community Disadvantage. In *Community Quality-of-Life Indicators: Best Cases VII*; Holden, M., Phillips, R., Stevens, C., Eds.; Springer: Cham, Swizterland, 2017; pp. 113–133. [CrossRef]
18. CSDH. *Closing the Gap in a Generation: Health Equity through Action on the Social Determinants of Health*; Final Report of the Commission on Social Determinants of Health; Commission on Social Determinants of Health, World Health Organisation: Geneva, Switzerland, 2008; Volume 2015.
19. Spoer, B.R.; Feldman, J.M.; Gofine, M.L.; Levine, S.E.; Wilson, A.R.; Breslin, S.B.; Thorpe, L.E.; Gourevitch, M.N. Peer Reviewed: Health and Health Determinant Metrics for Cities: A Comparison of County and City-Level Data. *Prev. Chronic. Dis.* **2020**, *17*, E137. [CrossRef]
20. McKinlay, J.B. A case for refocusing upstream: The political economy of illness. *IAPHS Occas. Class.* **2019**, *1*, 1–10.
21. Rose, G.; Khaw, K.; Marmot, M. Rose's Strategy of Preventive Medicine. 2008. Available online: http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780192630971.001.0001/acprof-9780192630971 (accessed on 27 January 2021).
22. Zhang, X.; Pérez-Stable, E.J.; Bourne, P.E.; Peprah, E.; Duru, O.K.; Breen, N.; Berrigan, D.; Wood, F.; Jackson, J.S.; Wong, D.W.; et al. Big Data Science: Opportunities and Challenges to Address Minority Health and Health Disparities in the 21st Century. *Ethn. Dis.* **2017**, *27*, 95–106. [CrossRef] [PubMed]
23. Badland, H.; Pearce, J. Liveable for whom? Prospects of urban liveability to address health inequities. *Soc. Sci. Med.* **2019**, *232*, 94–105. [CrossRef] [PubMed]
24. Marmot, M. Social determinants of health inequalities. *Lancet* **2005**, *365*, 1099–1104. [CrossRef]
25. Marmot, M.; Wilkinson, R. *Social Determinants of Health*, 2nd ed.; Oxford University Press: Oxford, UK, 2006; p. 366.
26. Marmot, M.; Stansfeld, S.; Patel, C.; North, F.; Head, J.; White, I.; Brunner, E.; Feeney, A.; Smith, G. Health inequalities among British civil servants: The Whitehall II study. *Lancet* **1991**, *337*, 1387–1393. [CrossRef]
27. Poulton, R.; Caspi, A.; Milne, B.J.; Thomson, W.M.; Taylor, A.; Sears, M.R.; Moffitt, T.E. Association between children's experience of socioeconomic disadvantage and adult health: A life-course study. *Lancet* **2002**, *360*, 1640–1645. [CrossRef]
28. Wilkinson, R.G.; Marmot, M.G. *Social Determinants of Health: The Solid Facts*; World Health Organization: Copenhagen, Denmark, 2003.
29. Bloom, D.E.; Canning, D. Commentary: The Preston Curve 30 years on: Still sparking fires. *Int. J. Epidemiol.* **2007**, *36*, 498–499. [CrossRef]
30. Kartman, L. Human Ecology and Public Health. *Am. J. Public Health Nations Health* **1967**, *57*, 737–750. [CrossRef]
31. World Bank. (Ed.) Urban Population. In *World Development Indicators*; Wold Bank: Washingon, DC, USA, 2017.
32. Antonovsky, A. The salutogenic model as a theory to guide health promotion. *Health Promot. Int.* **1996**, *11*, 11–18. [CrossRef]
33. Marmot, M.; Bell, R. Action on Health Disparities in the United States Commission on Social Determinants of Health. *JAMA J. Am. Med Assoc.* **2009**, *301*, 1169–1171. [CrossRef]
34. Solar, O.; Irwin, A. A Conceptual Framework for Action on the Social Determinants of Health. In *Social Determinants of Health Discussion Paper 2 in Policy and Practice*; World Health Organization: Geneva, Switzerland, 2010.
35. Barton, H.; Grant, M. A health map for the local human habitat. *J. R. Soc. Promot. Health* **2006**, *126*, 252–253. [CrossRef] [PubMed]
36. EIU. The Global Liveability Index 2021. In *A Free Overview*; The Economist: Cabot Square, UK, 2022.
37. Browne, G.R.; Lowe, M. Liveability as determinant of health: Testing a new approach for health impact assessment of major infrastructure. *Environ. Impact Assess. Rev.* **2021**, *87*, 106546. [CrossRef]
38. Lowe, M.; Whitzman, C.; Badland, H.; Davern, M.; Hes, D.; Aye, L.; Butterworth, I.; Giles-Corti, W. *Liveable, Healthy, Sustainable: What are the Key Indicators for Melbourne Neighbourhoods?* Department of Health and Human Services: Victoria, Australia, 2013.
39. Badland, H.; Whitzman, C.; Lowe, M.; Davern, M.; Aye, L.; Butterworth, I.; Hes, D.; Giles-Corti, B. Urban liveability: Emerging lessons from Australia for exploring the potential for indicators to measure the social determinants of health. *Soc. Sci. Med.* **2014**, *111*, 64–73. [CrossRef]
40. Bloemsma, L.D.; Wijga, A.H.; Klompmaker, J.O.; Janssen, N.A.; Smit, H.A.; Koppelman, G.; Brunekreef, B.; Lebret, E.; Hoek, G.; Gehring, U. The associations of air pollution, traffic noise and green space with overweight throughout childhood: The PIAMA birth cohort study. *Environ. Res.* **2018**, *169*, 348–356. [CrossRef]
41. Marshall, J.D.; Brauer, M.; Frank, L.D. Healthy Neighborhoods: Walkability and Air Pollution. *Environ. Health Perspect.* **2009**, *117*, 1752–1759. [CrossRef] [PubMed]
42. Prochaska, J.; Nolen, A.B.; Kelley, H.; Sexton, K.; Linder, S.H.; Sullivan, J. Social Determinants of Health in Environmental Justice Communities: Examining Cumulative Risk in Terms of Environmental Exposures and Social Determinants of Health. *Hum. Ecol. Risk Assess. Int. J.* **2014**, *20*, 980–994. [CrossRef] [PubMed]
43. US EPA. Environmental Justice Timeline. Environmental Justice. 2021. Available online: https://www.epa.gov/environmentaljustice/environmental-justice-timeline (accessed on 4 April 2021).
44. Baum, F. *The New Public Health*; Oxford University Press: Oxford, UK, 2016.
45. Walker, G.P. Environmental justice, impact assessment and the politics of knowledge: The implications of assessing the social distribution of environmental outcomes. *Environ. Impact Assess. Rev.* **2010**, *30*, 312–318. [CrossRef]

46. Pasetto, R.; Mattioli, B.; Marsili, D. Environmental justice in industrially contaminated sites. A review of scientific evidence in the WHO European region. *Int. J. Environ. Res. Public Health* **2019**, *16*, 998. [CrossRef]
47. Collins, T.W.; Grineski, S.E.; Nadybal, S. Social disparities in exposure to noise at public schools in the contiguous United States. *Environ. Res.* **2019**, *175*, 257–265. [CrossRef]
48. Morelli, X.; Gabet, S.; Rieux, C.; Bouscasse, H.; Mathy, S.; Slama, R. Which decreases in air pollution should be targeted to bring health and economic benefits and improve environmental justice? *Environ. Int.* **2019**, *129*, 538–550. [CrossRef]
49. Almansour, K.S.; Arisco, N.J.; Woo, M.K.; Young, A.S.; Adamkiewicz, G.; Hart, J.E. Playground lead levels in rubber, soil, sand, and mulch surfaces in Boston. *PLoS ONE* **2019**, *14*, e0216156. [CrossRef] [PubMed]
50. Schaider, L.A.; Swetschinski, L.; Campbell, C.; Rudel, R.A. Environmental justice and drinking water quality: Are there socioeconomic disparities in nitrate levels in U.S. drinking water? *Environ. Health* **2019**, *18*, 1–15. [CrossRef] [PubMed]
51. Zwickl, K. The demographics of fracking: A spatial analysis for four U.S. states. *Ecol. Econ.* **2019**, *161*, 202–215. [CrossRef]
52. Hilburn, A.; Fry, M. Empirical environmental justice research in hydrocarbon extraction areas: Examining current approaches outside the U.S. using a Mexican case study. *Appl. Geogr.* **2019**, *107*, 63–71. [CrossRef]
53. Liao, K.-H.; Chan, J.K.H.; Huang, Y.-L. Environmental justice and flood prevention: The moral cost of floodwater redistribution. *Landsc. Urban Plan.* **2019**, *189*, 36–45. [CrossRef]
54. Harris, K.M. Mapping inequality: Childhood asthma and environmental injustice, a case study of St. Louis, Missouri. *Soc. Sci. Med.* **2019**, *230*, 91–110. [CrossRef]
55. Yi, H.; Kreuter, U.P.; Han, D.; Güneralp, B. Social segregation of ecosystem services delivery in the San Antonio region, Texas, through 2050. *Sci. Total Environ.* **2019**, *667*, 234–247. [CrossRef]
56. Łaszkiewicz, E.; Czembrowski, P.; Kronenberg, J. Can proximity to urban green spaces be considered a luxury? Classifying a non-tradable good with the use of hedonic pricing method. *Ecol. Econ.* **2019**, *161*, 237–247. [CrossRef]
57. Montgomery, M.C.; Chakraborty, J.; Grineski, S.E.; Collins, T.W. An environmental justice assessment of public beach access in Miami, Florida. *Appl. Geogr.* **2015**, *62*, 147–156. [CrossRef]
58. Deacon, L.; Baxter, J. No opportunity to say no: A case study of procedural environmental injustice in Canada. *J. Environ. Plan. Manag.* **2013**, *56*, 607–623. [CrossRef]
59. Barnes, J.H.; Chatterton, T.J.; Longhurst, J.W.S. Emissions vs exposure: Increasing injustice from road traffic-related air pollution in the United Kingdom. *Transport. Res. Part D Transp. Environ.* **2019**, *73*, 56–66. [CrossRef]
60. Rachele, J.N.; Giles-Corti, B.; Turrell, G. Neighbourhood disadvantage and self-reported type 2 diabetes, heart disease and comorbidity: A cross-sectional multilevel study. *Ann. Epidemiol.* **2016**, *26*, 146–150. [CrossRef]
61. Luo, J.; Hendryx, M. Environmental Carcinogen Releases and Lung Cancer Mortality in Rural-Urban Areas of the United States. *J. Rural Health* **2011**, *27*, 342–349. [CrossRef]
62. Bravo, M.A.; Anthopolos, R.; Bell, M.L.; Miranda, M.L. Racial isolation and exposure to airborne particulate matter and ozone in understudied US populations: Environmental justice applications of downscaled numerical model output. *Environ. Int.* **2016**, *92–93*, 247–255. [CrossRef]
63. Tanzer, R.; Malings, C.; Hauryliuk, A.; Subramanian, R.; Presto, A.A. Demonstration of a Low-Cost Multi-Pollutant Network to Quantify Intra-Urban Spatial Variations in Air Pollutant Source Impacts and to Evaluate Environmental Justice. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2523. [CrossRef]
64. Chakraborty, J.; Green, D. The relationship between industrial air pollution and social disadvantage in Australia: National and regional inequities. *Air Qual. Clim. Chang.* **2014**, *48*, 35–38.
65. Kweon, B.-S.; Mohai, P.; Lee, S.; Sametshaw, A.M. Proximity of public schools to major highways and industrial facilities, and students' school performance and health hazards. *Environ. Plan. B Urban Anal. City Sci.* **2016**, *45*, 312–329. [CrossRef]
66. Riva, M.; Terashima, M.; Curtis, S.; Shucksmith, J.; Carlebach, S. Coalfield health effects: Variation in health across former coalfield areas in England. *Health Place* **2011**, *17*, 588–597. [CrossRef]
67. Chakraborty, J.; Green, D. Australia's first national level quantitative environmental justice assessment of industrial air pollution. *Environ. Res. Lett.* **2014**, *9*, 044010. [CrossRef]
68. Richardson, E.A.; Shortt, N.K.; Mitchell, R.J. The Mechanism behind Environmental Inequality in Scotland: Which Came First, the Deprivation or the Landfill? *Environ. Plan. A Econ. Space* **2010**, *42*, 223–240. [CrossRef]
69. Duhme, H.; Weiland, S.K.; Keil, U.; Kraemer, B.; Schmid, M.; Stender, M.; Chambless, L. The Association between Self-Reported Symptoms of Asthma and Allergic Rhinitis and Self-Reported Traffic Density on Street of Residence in Adolescents. *Epidemiology* **1996**, *7*, 578–582. [CrossRef]
70. ABS. Main Structure. 1270.0.55.001—Australian Statistical Geography Standard (ASGS): Volume 1—Main Structure and Greater Capital City Statistical Areas, July 2016. 2016. Available online: https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1270.0.55.001~July%202016~Main%20Features~Main%20structure~10002 (accessed on 7 April 2021).
71. Rossiter, K. What Are Census Blocks? Random Samplings. 2011. Available online: https://www.census.gov/newsroom/blogs/random-samplings/2011/07/what-are-census-blocks.html (accessed on 20 May 2021).
72. Schaeffer, Y.; Tivadar, M. Measuring Environmental Inequalities: Insights from the Residential Segregation Literature. *Ecol. Econ.* **2019**, *164*, 106329. [CrossRef]

73. Morrison, S.; Fordyce, F.M.; Scott, E.M. An initial assessment of spatial relationships between respiratory cases, soil metal content, air quality and deprivation indicators in Glasgow, Scotland, UK: Relevance to the environmental justice agenda. *Environ. Geochem. Health* **2013**, *36*, 319–332. [CrossRef]
74. Spina, F.; McCormack, P.D.; Clarke, K.; Walfield, S. Environmental Enforcement: An Exploration of Latino Political Representation. *Sociol. Perspect.* **2019**, *62*, 308–324. [CrossRef]
75. Allen, S.; Fanucchi, M.V.; McCormick, L.C.; Zierold, K.M. The Search for Environmental Justice: The Story of North Birmingham. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2117. [CrossRef]
76. Lado, M.E. Toward Civil Rights Enforcement in the Environmental Justice Context: Step One: Acknowledging the Problem. *Environ. Law Rev.* **2017**, *29*, 1–49.
77. Stiglitz, J.E.; Sen, A.; Fitoussi, J.P. *Report by the Commission on the Measurement of Economic Performance and Social Progress*; Eurostat: Luxembourg, 2009.
78. Johnson, B.B. Acculturation, ethnicity, and air pollution perceptions. *Risk Anal. Int. J.* **2011**, *31*, 984–999. [CrossRef]
79. Chakraborty, J.; Collins, T.W.; Grineski, S.E.; Maldonado, A. Racial differences in perceptions of air pollution health risk: Does environmental exposure matter? *Int. J. Environ. Res. Public Health* **2017**, *14*, 116. [CrossRef]
80. Todd, H.; Zografos, C. Justice for the Environment: Developing a Set of Indicators of Environmental Justice for Scotland. *Environ. Values* **2005**, *14*, 483–501. [CrossRef]
81. Lingard, H.; Hallowell, M.; Salas, R.; Pirzadeh, P. Leading or lagging? Temporal analysis of safety indicators on a large infrastructure construction project. *Saf. Sci.* **2017**, *91*, 206–220. [CrossRef]
82. Marr, B. What's The Difference Between Lagging and Leading Indicators? In *Forbes (online)*; Integrated Whale Media Investments: Jersey City, NJ, USA, 2020.
83. Chakraborty, J.; Armstrong, M.P. Exploring the Use of Buffer Analysis for the Identification of Impacted Areas in Environmental Equity Assessment. *Cartogr. Geogr. Inf. Syst.* **1997**, *24*, 145–157. [CrossRef]
84. Yoon, D.K.; Kang, J.E.; Park, J. Exploring Environmental Inequity in South Korea: An Analysis of the Distribution of Toxic Release Inventory (TRI) Facilities and Toxic Releases. *Sustainability* **2017**, *9*, 1886. [CrossRef]
85. Havard, S.; Reich, B.J.; Bean, K.; Chaix, B. Social inequalities in residential exposure to road traffic noise: An environmental justice analysis based on the RECORD Cohort Study. *Occup. Environ. Med.* **2011**, *68*, 366–374. [CrossRef]
86. Hopkins, A. Thinking about process safety indicators. *Saf. Sci.* **2009**, *47*, 460–465.
87. Reiman, T.; Pietikäinen, E. Leading indicators of system safety – Monitoring and driving the organizational safety potential. *Saf. Sci.* **2011**, *50*, 1993–2000. [CrossRef]
88. Luo, J.; Hendryx, M.; Ducatman, A. Association between Six Environmental Chemicals and Lung Cancer Incidence in the United States. *J. Environ. Public Health* **2011**, *2011*, 463701. [CrossRef] [PubMed]
89. Navi, M.; Pisaniello, D.; Hansen, A.; Nitschke, M. Potential Health Outcome and Vulnerability Indicators of Climate Change for Australia: Evidence for Policy Development. *Aust. J. Public Adm.* **2016**, *76*, 160–175. [CrossRef]
90. Niemeijer, D.; de Groot, R.S. A conceptual framework for selecting environmental indicator sets. *Ecol. Indic.* **2008**, *8*, 14–25. [CrossRef]
91. Van Oudenhoven, A.P.; Petz, K.; Alkemade, R.; Hein, L.; de Groot, R.S. Framework for systematic indicator selection to assess effects of land management on ecosystem services. *Ecol. Indic.* **2012**, *21*, 110–122. [CrossRef]
92. Gilderbloom, J.H.; Meares, W.L.; Squires, G.D. Pollution, place, and premature death: Evidence from a mid-sized city. *Local Environ.* **2020**, *25*, 419–432. [CrossRef]
93. ABS; IRSD. The Index of Relative Socio-Economic Disadvantage. 2018. Available online: https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2033.0.55.001~{}2016~{}Main%20Features~{}IRSD~{}19 (accessed on 8 February 2021).
94. Hu, X.; Waller, L.A.; Lyapustin, A.; Wang, Y.; Al-Hamdan, M.Z.; Crosson, W.L.; Estes, M.G.; Estes, S.M.; Quattrochi, D.A.; Puttaswamy, S.J.; et al. Estimating ground-level PM2.5 concentrations in the Southeastern United States using MAIAC AOD retrievals and a two-stage model. *Remote Sens. Environ.* **2014**, *140*, 220–232. [CrossRef]
95. Claudio, L.; Tulton, L.; Doucette, J.; Landrigan, P.J. Socioeconomic factors and asthma hospitalization rates in New York City. *J. Asthma* **1999**, *36*, 343–350. [CrossRef] [PubMed]
96. Orta-Martínez, M.; Pellegrini, L.; Arsel, M. "The squeaky wheel gets the grease"? The conflict imperative and the slow fight against environmental injustice in northern Peruvian Amazon. *Ecol. Soc.* **2018**, *23*, 7. [CrossRef]
97. Binder, T.; De Michelis, G.; Ehn, P.; Jacucci, G.; Linde, P. *Design Things*; MIT Press: Cambridge, MA, USA, 2011.
98. Mohajan, H.K. Two criteria for good measurements in research: Validity and reliability. *Ann. Spiru Haret Univ. Econ. Ser.* **2017**, *17*, 59–82. [CrossRef]
99. Cole, D.C.; Eyles, J.; Gibson, B.L. Indicators of human health in ecosystems: What do we measure? *Sci. Total Environ.* **1998**, *224*, 201–213. [CrossRef]
100. Higgs, C.; Badland, H.; Simons, K.; Knibbs, L.; Giles-Corti, B. The Urban Liveability Index: Developing a policy-relevant urban liveability composite measure and evaluating associations with transport mode choice. *Int. J. Health Geogr.* **2019**, *18*, 14. [CrossRef]
101. Kitchin, R.; Lauriault, T.P.; McArdle, G. Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards. *Reg. Stud. Reg. Sci.* **2015**, *2*, 6–28. [CrossRef]
102. Collins, M.B.; Munoz, I.; JaJa, J. Linking 'toxic outliers' to environmental justice communities. *Environ. Res. Lett.* **2016**, *11*, 015004. [CrossRef]

103. Anand, S. The concern for equity in health. *J. Epidemiol. Community Health* **2002**, *56*, 485–487. [CrossRef]
104. Klasen, S. The efficiency of equity. *Rev. Political Econ.* **2008**, *20*, 257–274. [CrossRef]
105. Spina, F. Environmental justice and patterns of state inspections. *Soc. Sci. Q.* **2015**, *96*, 417–429. [CrossRef]
106. Zhao, J.; Gladson, L.; Cromar, K. A novel environmental justice indicator for managing local air pollution. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1260. [CrossRef] [PubMed]
107. WHO. *Ambient (Outdoor) Air Quality and Health*; The World Health Organization: Geneva, Switzerland, 2015.
108. Johnson Gaither, C.; Afrin, S.; Garcia-Menendez, F.; Odman, M.T.; Huang, R.; Goodrick, S.; Ricardo da Silva, A. African American Exposure to Prescribed Fire Smoke in Georgia, USA. *Int. J. Environ. Res. Public Health* **2019**, *16*, 3079. [CrossRef] [PubMed]
109. Gouveia, N.; Bremner, S.; Novaes, H. Association between ambient air pollution and birth weight in São Paulo, Brazil. *J. Epidemiol. Community Health* **2004**, *58*, 11–17. [CrossRef] [PubMed]
110. Guo, H.; Wang, T.; Blake, D.; Simpson, I.; Kwok, Y.; Li, Y. Regional and local contributions to ambient non-methane volatile organic compounds at a polluted rural/coastal site in Pearl River Delta, China. *Atmos. Environ.* **2006**, *40*, 2345–2359. [CrossRef]
111. Zielinska, B.; Fujita, E.; Ollison, W.; Campbell, D.; Sagebiel, J. Quantification of personal exposure concentrations to gasoline vehicle emissions in high-end exposure microenvironments: Effects of fuel and season. *J. Air Waste Manag. Assoc.* **2012**, *62*, 1346–1357. [CrossRef] [PubMed]
112. Malmqvist, E.; Rignell-Hydbom, A.; Tinnerberg, H.; Björk, J.; Stroh, E.; Jakobsson, K.; Rittner, R.; Rylander, L. Maternal exposure to air pollution and birth outcomes. *Environ. Health Perspect.* **2011**, *119*, 553–558. [CrossRef] [PubMed]
113. Turner, L.R.; Connell, D.; Tong, S. The effect of heat waves on ambulance attendances in Brisbane, Australia. *Prehosp. Disaster Med.* **2013**, *28*, 482–487. [CrossRef] [PubMed]
114. Haberle, S.G.; Bowman, D.M.; Newnham, R.M.; Johnston, F.H.; Beggs, P.J.; Buters, J.; Campbell, B.; Erbas, B.; Godwin, I.; Green, B.J. The macroecology of airborne pollen in Australian and New Zealand urban areas. *PLoS ONE* **2014**, *9*, e97925. [CrossRef] [PubMed]
115. Darwish, T.; Bakar, K.A. Traffic density estimation in vehicular ad hoc networks: A review. *Ad Hoc Netw.* **2015**, *24*, 337–351. [CrossRef]
116. Walter, C.; Schneider-Futschik, E.; Irving, L. Traffic pollution near childcare centres in Melbourne. *Aust. N. Z. J. Public Health* **2019**, *43*, 410–412. [CrossRef]
117. Wiseman, J.; McLeod, J.; Zubrick, S.R. Promoting mental health and well-being: Integrating individual, organisational and community-level indicators. *Health Promot. J. Aust.* **2007**, *18*, 198–207. [CrossRef] [PubMed]
118. Rogalsky, D.K.; Mendola, P.; Metts, T.A.; Martin, W.J. Estimating the number of low-income americans exposed to household air pollution from burning solid fuels. *Environ. Health Perspect.* **2014**, *122*, 806–810. [CrossRef]
119. CEHTP. *Agricultural Pesticide Use Near Public Schools in California*; California Department of Public Health and the Public Health Institute: San Francisco, CA, USA, 2014.
120. Rüttenauer, T. Neighbours matter: A nation-wide small-area assessment of environmental inequality in Germany. *Soc. Sci. Res.* **2018**, *70*, 198–211. [CrossRef] [PubMed]
121. EPAV. Beach Report–Water Quality Forecast. Available online: https://yarraandbay.vic.gov.au/beach-report (accessed on 22 September 2019).
122. CES. State of the Environment Part 4, Coasts Estuaries & The Sea. In *Commissioner for Environmental Sustainability*; Victorian Government: Melbourne, Australia, 2008.
123. Boyd, G.R.; Palmeri, J.M.; Zhang, S.; Grimm, D.A. Pharmaceuticals and personal care products (PPCPs) and endocrine disrupting chemicals (EDCs) in stormwater canals and Bayou St. John in New Orleans, Louisiana, USA. *Sci. Total Environ.* **2004**, *333*, 137–148. [CrossRef] [PubMed]
124. Fielding, J.L. Flood risk and inequalities between ethnic groups in the floodplains of England and Wales. *Disasters* **2018**, *42*, 101–123. [CrossRef] [PubMed]
125. Chakraborty, J.; Collins, T.W.; Grineski, S.E. Exploring the environmental justice implications of Hurricane Harvey flooding in Greater Houston, Texas. *Am. J. Public Health* **2019**, *109*, 244–250. [CrossRef]
126. Sobotta, R.R.; Campbell, H.E.; Owens, B.J. Aviation noise and environmental justice: The barrio barrier. *J. Reg. Sci.* **2007**, *47*, 125–154. [CrossRef]
127. Lakes, T.; Brückner, M.; Krämer, A. Development of an environmental justice index to determine socio-economic disparities of noise pollution and green space in residential areas in Berlin. *J. Environ. Plan. Manag.* **2014**, *57*, 538–556. [CrossRef]
128. Richardson, M.J.; Madrigal, D.S.; Wilkie, A.; Wong, M.; Roberts, E. Environmental Health Tracking Improves Pesticide Use Data to Enable Research and Inform Public Health Actions in California. *J. Public Health Manag. Pract.* **2017**, *23*, S97–S104. [CrossRef]
129. Tolhurst, T.; Goodhue, R.; DeMars, C.; Zhang, M. Environmental Justice and Self-Regulation of Pesticide Applications: Evidence from California. In Proceedings of the Agricultural & Applied Economics Association Annual Meeting, Atlanta, GA, USA, 21–23 July 2019.
130. Blue Environment. *Hazardous Waste in Australia 2017*; Department of the Environment and Energy: Melbourne, Australia, 2017.
131. VAGO. *Recovering and Reprocessing Resources from Waste*; Victorian Government: Melbourne, Australia, 2019.
132. Arundel, J.; Lowe, M.; Hooper, P.; Roberts, R.; Rozek, J.; Higgs, C.; Giles-Corti, B. *Creating Liveable Cities in Australia: Mapping Urban Policy Implementation and Evidence-Based National Liveability Indicators*; Centre for Urban Research (CUR): Melbourne, Australia, 2017.

133. BOM. Observation of Rainfall. Available online: http://www.bom.gov.au/climate/cdo/about/rain-measure.shtml (accessed on 22 September 2019).
134. Vaughan, K.B.; Kaczynski, A.T.; Wilhelm Stanis, S.A.; Besenyi, G.M.; Bergstrom, R.; Heinrich, K.M. Exploring the distribution of park availability, features, and quality across Kansas City, Missouri by income and race/ethnicity: An environmental justice investigation. *Ann. Behav. Med.* **2013**, *45*, S28–S38. [CrossRef]
135. Pereira, G.; Christian, H.; Foster, S.; Boruff, B.J.; Bull, F.; Knuiman, M.; Giles-Corti, B. The association between neighborhood greenness and weight status: An observational study in Perth Western Australia. *Environ. Health* **2013**, *12*, 49. [CrossRef]
136. Wilson, L.-A.; Giles-Corti, B.; Turrell, G. The association between objectively measured neighbourhood features and walking for transport in mid-aged adults. *Local Environ.* **2012**, *17*, 131–146. [CrossRef]
137. Davern, M.; Gunn, L.; Whitzman, C.; Higgs, C.; Giles-Corti, B.; Simons, K.; Villanueva, K.; Mavoa, S.; Roberts, R.; Badland, H. Using spatial measures to test a conceptual model of social infrastructure that supports health and wellbeing. *Cities Health* **2017**, *1*, 194–209. [CrossRef]
138. Smit, L.A.; Hooiveld, M.; van der Sman-de Beer, F.; Opstal-van Winden, A.W.; Beekhuizen, J.; Wouters, I.M.; Yzermans, C.J.; Heederik, D. Air pollution from livestock farms, and asthma, allergic rhinitis and COPD among neighbouring residents. *Occup. Environ. Med.* **2014**, *71*, 134–140. [CrossRef]
139. WHO. *ICD-11 for Mortality and Morbidity Statistics*; World Health Organization: Geneva, Switzerland, 2019.
140. Rachele, J.N.; Kavanagh, A.; Brown, W.J.; Healy, A.M.; Schmid, C.J.; Turrell, G. Neighborhood socioeconomic disadvantage and body mass index among residentially stable mid-older aged adults: Findings from the HABITAT multilevel longitudinal study. *Prev. Med.* **2017**, *105*, 271–274. [CrossRef]
141. Badland, H.; Turrell, G.; Giles-Corti, B. Who does well where? Exploring how self-rated health differs across diverse people and neighborhoods. *Health Place* **2013**, *22*, 82–89. [CrossRef]
142. Richardson, E.A.; Pearce, J.; Mitchell, R.; Kingham, S. Role of physical activity in the relationship between urban green space and health. *Public Health* **2013**, *127*, 318–324. [CrossRef]
143. Ware, J.; Kosinski, M.; Gandek, B. *SF-36 Health Survey: Manual and Interpretation Guide Lincoln*; Quality Metric Incorporated: Johnston, RI, USA, 2000.
144. Cummins, R.A.; Eckersley, R.; Pallant, J.; Van Vugt, J.; Shelley, J.; Pusey, M.; Misajon, R.A. *Australian Unity Wellbeing Index*; Australian Centre on Quality of Life, Deakin University: Melbourne, Australia, 2001.
145. Davern, M. *The Subjective Wellbeing Evaluation Toolkit: A Resource to Support the Use of Subjective Wellbeing to Measure the Impact of Community Programs and Public Policy Initiatives*; University of Melbourne: Melbourne, Australia, 2016.
146. WHO. *Global Nutrition Targets 2025: Low Birth Weight Policy Brief*; World Health Organization: Geneva, Switzerland, 2019.
147. Turrell, G.; Haynes, M.; Burton, N.W.; Giles-Corti, B.; Oldenburg, B.; Wilson, L.-A.; Giskes, K.; Brown, W.J. Neighborhood disadvantage and physical activity: Baseline results from the HABITAT multilevel longitudinal study. *Ann. Epidemiol.* **2010**, *20*, 171–181. [CrossRef]
148. Rachele, J.N.; Wood, L.; Nathan, A.; Giskes, K.; Turrell, G. Neighbourhood disadvantage and smoking: Examining the role of neighbourhood-level psychosocial characteristics. *Health Place* **2016**, *40*, 98–105. [CrossRef]
149. Kamruzzaman, M.; Shatu, F.M.; Hine, J.; Turrell, G. Commuting mode choice in transit oriented development: Disentangling the effects of competitive neighbourhoods, travel attitudes, and self-selection. *Transp. Policy* **2015**, *42*, 187–196. [CrossRef]
150. Greife, M.; Stretesky, P.B.; Shelley, T.O.C.; Pogrebin, M. Corporate environmental crime and environmental justice. *Crim. Justice Policy Rev.* **2017**, *28*, 327–346. [CrossRef]
151. Wilson, S.M.; Richard, R.; Joseph, L.; Williams, E. Climate change, environmental justice, and vulnerability: An exploratory spatial analysis. *Environ. Justice* **2010**, *3*, 13–19. [CrossRef]
152. Lynch, M.J.; Stretesky, P.B.; Long, M.A. Environmental crime prosecutions in Ireland, 2004–2014. *Int. J. Comp. Appl. Crim. Justice* **2019**, *43*, 277–293. [CrossRef]
153. Potvin, S.; Apparicio, P.; Séguin, A.-M. The spatial distribution of noise barriers in Montreal: A barrier to achieve environmental equity. *Transp. Res. Part D Transp. Environ.* **2019**, *72*, 83–97. [CrossRef]
154. Potvin, S. *La Distribution Spatiale des Écrans Antibruit dans la Région de Montréal: Une Barrière Sonore à L'équité Environnementale?* Institut National de la Recherche Scientifique, Université du Québec: Québec, Australia, 2019.
155. Carrier, M.; Apparicio, P.; Séguin, A.-M.; Crouse, D. School locations and road transportation nuisances in Montreal: An environmental equity diagnosis. *Transp. Policy* **2019**, *81*, 302–310. [CrossRef]
156. Ruá, M.J.; Huedo, P.; Cabeza, M.; Saez, B.; Agost-Felip, R. A model to prioritise sustainable urban regeneration in vulnerable areas using SWOT and CAME methodologies. *J. Hous. Built Environ.* **2021**, *36*, 1603–1627. [CrossRef]
157. Bond. *Principles and Checklist for Assessing the Quality of Evidence*; Bond, the International Development Network: London, UK, 2018.