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PILLAR 3

STATE OF THE ART

[ELLIS]

Monitoring and Mitigating Environmental Health Inequalities in Belgium

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[Introduction]

The conceptual framework for ELLIS is presented in Figure 1. Three dimensions are of interest to studying environmental health inequalities–i.e., socio-economic deprivation, environmental exposure, and health outcomes. Pairwise integration of these dimensions gives rise to three concepts¬–i.e., **health inequalities, environmental inequalities, and environmental health**. Each of these concepts have been well described in national and international literature; however, the integration of all three, leading to **environmental health inequalities**, has so far received little attention.

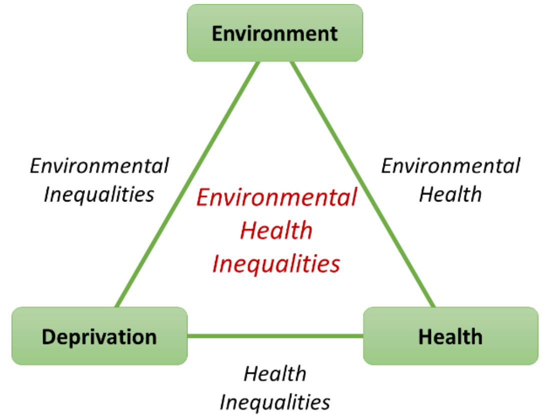

Figure 1. Environmental health inequalities integrate socio-economic deprivation, environmental exposure, and health outcomes.

The overall objectives of ELLIS will be to develop tools to a) **quantify and monitor the extent of socioeconomic differences in environmental burden of disease in Belgium**; and b) **assess the impact of policy measures on environmental health inequalities**.

[State of the art]

There is an increasing body of evidence showing that environmental stressors can increase the risk of illness and premature mortality. For example, particulate matter triggers lung cancer (Raaschou-Nielsen et al., 2013) and noise increases the risk of heart attack (van Kempen & Babish, 2012). Conversely, the natural environment can also enhance health, e.g., contact with nature in parks and gardens (green spaces) is associated with increased physical activity, reduced stress and improved well-being. Consequently, governments worldwide aim to mitigate the negative health effects of environmental exposures and secure environmental health benefits. As exposures are not equal among all segments of the population, it is furthermore important to understand and mitigate inequalities in environmental health. Indeed, some already socially vulnerable groups of the population are more exposed to environmental risks in their living, working, and social environments. This differential exposure can accentuate or attenuate the existing socio-economic health inequalities. For example, in areas where people have easier access to green space, differences in mortality for all causes and cardiovascular diseases are less pronounced than in areas where access to green space is more difficult (Mitchell & Popham, 2008). However, discrimination in relation to living environment is a dimension that is often overlooked in practice and has been insufficiently studied.

Guiding principles: inequalities, inequities, and socio-economic deprivation

Health inequalities (or disparities) refer to differences in the health status between individuals or groups of people (Kawachi et al., 2002). It is a descriptive term that does not imply any moral judgment on whether the observed differences are fair or not. In contrast, **health inequities** refer specifically to those inequalities that are considered unfair and potentially avoidable (Kawachi et al., 2002). Inequity in health is therefore a normative concept, relying on social and ethical values in a given society (Whitehead, 1992).

In particular, **socioeconomic health inequalities** are disparities between people grouped according to some features of their underlying socioeconomic position (such as income, wealth, education or occupation). Socioeconomic health inequalities penalizing socially disadvantaged groups are one of the most consistent, and persistent, findings in epidemiology (Mackenbach, 2012), for almost every health outcome and socioeconomic indicator. They are usually considered unfair and avoidable, and therefore most often qualify as "inequities"; however, socioeconomic inequalities are often easier to measure, and have therefore been the focus of most studies. In line with the attention drawn to health inequalities, increased attention has been drawn to **environmental inequalities**—i.e., (socioeconomic) differences in environmental exposure between individuals or groups of people. Quite often, this is referred to by its complement, i.e., environmental justice (Brulle & Pellow, 2006). As for health inequalities, environmental inequalities are widespread and persistent, as was recently inventoried in the Second Assessment Report on Environmental health inequalities in Europe by the World Health Organization Regional Office for Europe (WHO/EURO, 2019). The report concludes with a strong call for action to identify environmental inequalities at country level and to take action to protect those who carry a disproportionate environmental burden.

When studying socioeconomic inequalities, developing a measure of the position of individuals or groups within society is a prerequisite. **Socio-economic status** refers to the social and economic factors that influence the position of individuals or groups within the fabric of a society. Its measurement includes one or more social characteristics, such as occupation, income, wealth and education. All of these domains capture distinct aspects of the socioeconomic position, and are correlated to each other, without being interchangeable (Shavers, 2007). While most studies focus on one indicator of socioeconomic position, it is increasingly recognized that different indicators may lead to subtle differences in terms of their effects, patterns and gradients (Gadeyne & Deboosere, 2006). The challenge is therefore to construct a multidimensional socioeconomic indicator. Townsend (1987) discusses the evolution of the concept of **area-based multiple deprivation indices**, introduced in the UK in the 1970s to support selective allocation of (scarce) resources to the more disparate areas. Townsend (1987) defined deprivation as "a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs", denoting a phenomenon more complex than poverty, associated with an accumulation of disadvantages. Based on 1981 census data, he combined four indicators (unemployment, household overcrowding, non-home ownership and non-car ownership) to create this index at the ecological level, offering a different perspective than that gained by income alone and highlighting the social aspects of deprivation that are relevant for health care planning and resources allocation. Since then, several other countries have developed indices of multiple deprivation (IMD), e.g. New Zealand (Exeter et al., 2017) and France (Rey et al., 2009). In Belgium, at the individual level, Eggerickx et al. (2018) defined an index of multiple deprivation based on educational level, occupation, and tenure status. Using this indicator, they divided the population in four social groups, and quantified the evolution of social inequalities in mortality. **So far, however, no area-level IMD has been developed or applied in Belgium, nor are IMDs used in policy-making.**

Health and environmental inequalities in Belgium

Despite the effectiveness of the Belgian social security and health care system, **socioeconomic health inequalities in Belgium** persist and even tend to widen over time. For example, analyses based on mortality data linked to census data highlighted a widening social gap in life expectancy at age 25 by educational level. Men with no education had a life expectancy at age 25 which was 5.2 years lower than men with tertiary education in the period 1991–1994, and this gap had increased to 7.5 years in 2001-2004 (Deboosere et al., 2009). A recent study based on data from the 2011 census showed that this gap has increased even further in recent years, especially among males (Renard et al., 2019). Eggerickx et al. (2018) made the same observation based on their index of multiple deprivation. Inequalities in mortality between the four social groups have indeed widened in recent decades. In addition, they observed that even within social groups, substantial differences in mortality persisted between Flanders and Wallonia and between the districts in Belgium. This suggests that, while spatial variations in mortality can largely be accounted by differences in the socio-economic characteristics of their populations, elements related to the physical, social and institutional environment of populations also contribute to these inequalities. **However, little research has been conducted on the environmental dimensions of these inequalities in Belgium.** The scales of the Belgian regions or districts, which are too large and includes very disparate "environments", are certainly not the most appropriate way to measure these effects. A more local approach is therefore warranted.

The exploration of **environmental inequalities in Belgium** is less well studied. Lejeune et al. (2016) used data from a household quality survey conducted in the Walloon Region and showed that families with lower incomes are more likely to live in households of lower quality, in more densely populated neighborhoods, and are exposed to higher levels of air pollution. The Belgian Health Interview Survey, conducted by Sciensano, revealed in 2013 that households in which the reference person has a high level of education and is the owner of his or her household are less likely to experience both indoor and outdoor environmental nuisances (Charafeddine, 2015). Finally, the aforementioned WHO Report on Environmental health inequalities in Europe probably provides the most complete overview of environmental inequalities in Belgium. One of the most striking findings is that between 2009 and 2016, Belgium showed one of the largest increases in inequality (comparing people below versus above relative poverty level) in self-reported noise annoyance.

Environmental burden of disease—quantifying "environmental health"

The previous sections focused on two of the three legs of the conceptual model presented in Figure 1—i.e., health inequalities and environmental inequalities. The key to closing the triangle is to introduce the concept of **environmental burden of disease (EBD)**. EBD aims to quantify the number of illnesses and deaths associated with various environmental stressors, as well as the health benefits of potential prevention and mitigation measures. Current EBD studies commonly use the Disability-Adjusted Life Year (DALY) metric as a common currency for integrating the effects of illness and premature death, thereby facilitating the comparison of the burden of various environmental stressors amongst each other and with other risk factors.

Two main approaches can be distinguished for quantifying EBD (Devleesschauwer et al., 2015). In the **bottom-up, risk assessment approach**, exposure data is combined with dose-response or relative risk functions to obtain a prediction of the number of cases or death that can be expected given current exposure levels. Two WHO projects (REVIHAAP & HRAPIE) have recently revised the dose-response and relative risk values for air pollution in Europe (Anenberg et al., 2016; Malmqvist et al., 2018). Although this approach is often applied in toxicology and environmental sciences, its main drawback is that the predicted number of cases or deaths are not bounded by the actual number of cases/deaths observed, and may therefore result in an estimate of attributable cases/deaths that exceeds the total number of cases/deaths. This problem can be circumvented using the **top-down, comparative risk assessment approach**. Here, a Population Attributable Fraction (PAF) is calculated from the exposure and dose-response data, corresponding to the proportion of cases/deaths that could have been avoided if no one would have been at risk of exposure. This is the approach used to estimate EBD globally and regionally both by the World Health Organization (Prüss-Ustün et al., 2019) and the Institute for Health Metrics and Evaluation, who leads the Global Burden of Disease study (GBD 2017 Risk Factor Collaborators, 2018). Few other studies have calculated EBD in Belgium using local data. Hanninen et al. (2014) report the results of the Environmental Burden of Disease in European countries (EBoDE) project, in which the burden from nine environmental risk factors in Belgium was quantified. Stassen et al. (2008) quantified the burden from transportation noise in Flanders. Currently, the Belgian Institute for Health Sciensano is conducting a national burden of disease study, calculating DALYs for key diseases and risk factors (Devleesschauwer, 2019). **At the moment, however, environmental stressors are not included in the framework, restricting a systematic assessment of the EBD in Belgium.**

Environmental health inequalities

After having introduced the individual dimensions and pairwise concepts, we can now introduce the concept of environmental health inequalities–i.e., the **socioeconomic inequalities in environmental burden of disease**.

An increasing number of studies quantifies socioeconomic health inequalities in burden of disease. For instance, Newton et al. (2015) and Steel et al. (2018) calculated absolute differences in burden of disease across area deprivation levels in the UK. Mesalles-Naranjo et al. (2018) calculated relative and slope indices of inequality to quantify inequalities in the mortality burden in Scotland by area deprivation. Ljung et al. (2005) calculated attributable fractions, as well as relative and slope indices of inequality to quantify inequalities in the burden of disease in Sweden by occupational level. **However, only few studies have explicitly addressed socioeconomic inequalities in environmental burden of disease.** In a report on "Environmental Gradients and Health Inequalities in the Americas" compiled by the Pan-American Health Organization, socioeconomic inequalities in EBD across and within the countries of the Americas were assessed at an ecological level. Specifically, they quantified inequalities in the burden of disease attributable to unimproved water and sanitation, using the slope index of inequality and the health concentration index.

Integrating dimensions at individual vs aggregate level

When studying health disparities, analyses are regularly conducted at the **individual level**. This individual perspective allows taking into account time lags between exposure and illness or death, and integrating other individual characteristics, such as marital, migratory or professional history (Crowder & Downey, 2010). Integration at individual level requires linkages between the microdata (i.e., the individual-level records), which exposes the researcher to possible sensitive data of individuals. In particular, when integrating environmental data, which are spatial by nature, researchers would be exposed to address data of the individuals. Linking microdata therefore requires approval from an ethical committee or privacy commission, including provisions to be taken to guarantee anonymity; for instance, the use of a third trusted party to perform the linkages and return the integrated dataset. Such approvals are typically provided for a well-defined project, with a predefined start and end date.

Alternatively, analyses can also conducted at **higher geographical levels**, such as neighborhoods or districts, to cover more "upstream" factors such as local social policies, the supply of public services (transportation, health care) or spatial planning. This aggregate perspective can help identify contextual effects that can attenuate or amplify compositional effects of neighborhoods. Integration at the aggregate level furthermore offers substantial practical benefits, since the only requirement is that all variables are available at the aggregate level. In light of sustainability of the tool developed in this project for informing policies, we therefore aim to explore the use of aggregate level.

Setting the aggregation level also determines the hypothesis in the analysis; the effect of deprivation can vary depending on whether absolute, contextual or relative income is used in the analysis (San Sebastián et al., 2018). Deprivation at an individual level is assumed to increase vulnerability to environmental stress, whereas living in a deprived neighborhood would increase exposure to environmental stressors.

Also, at the aggregate level, cumulative risk assessment can be conducted to study how multiple exposures and vulnerabilities from various sources contribute to shaping health inequalities over time. For example, contextual factors such as residential segregation, wealth distribution or social capital can affect the ability of local communities to influence public policies related to environmental health stressors (Soobader et al., 2006).

However, caution is warranted when building on aggregated data to draw conclusions at the individual level, due to the risk of **ecological fallacy**, especially when the areas considered are large and heterogeneous. Indeed, even if population exposure is well estimated, individual exposures can vary substantially, as a result of differences in concentrations at different places as well as individuals' own activity patterns. Associations (e.g., between deprivation and environmental exposure) observed at the aggregate level, may therefore differ in magnitude, or even direction, from the true associations that would be observed at individual level. **When integrating information at the aggregate level, the potential impact of ecological bias should therefore be assessed.**

Health (inequality) impact assessment of environmental stressors

In addition to merely monitoring the extent of environmental health inequalities, governments, also require tools that allow them to **define polices aimed at mitigating these inequalities**. Health impact assessment (HIA) is an increasingly important tool for informing public policy decisions that affect environmental conditions, and is actively supported by the World Health Organization (https://www.who.int/hia/en/). HIA quantitatively compares alternative policy scenarios with the "business-as-usual" scenario; results are often reported in terms of number of the cases, deaths, or DALYs, or changes in life expectancy, attributable to total exposure (=business-as-usual) or a change in exposure (=alternative policy options) (WHO/EURO, 2016).

There are a number of HIA tools available online, each differing in scope (from disease/risk-specific to supposedly generic tools) and usability. Fehr et al. (2012, 2016) reviewed publicly available computational tools for quantitative health modelling. Of the nearly 20 identified tools, only a few were sufficiently mature and available for public use. DYNAMO-HIA (Dynamic Modelling for Health Impact Assessment) is generic in scope, and illustrates the public health tradition in HIA. The HEIMTSA/INTARESE toolkit (Health and Environment Integrated Methodology and Toolbox for Scenario Assessment/Integrated Assessment of Health Risks of Environmental Stressors in Europe) focuses on environmental stressors and illustrates the environmental HIA tradition. Arenberg et al. (2016) reviewed 12 air pollution HIA tools, including the well-known AirQ+, developed and maintained by WHO.

While these tools could in principle be adapted to the Belgian context, they do not allow assessing impacts on health inequalities—highlighted by Fehr et al. (2012, 2016) as a key limitation of many currently available HIA tools. To date, probably the most comprehensive health inequality assessment tool is the Triple I toolkit (Informing Interventions to reduce health Inequalities), used by NHS Health Scotland to compare the potential population impact of interventions on health inequalities in Scotland (McAuley et al., 2016). This tool is however limited to the Scottish context, and currently only includes one environmental intervention, i.e., implementing 20 mph speed limits, modelled to reduce air pollution and road traffic accidents. **To support the mitigation of environmental health inequalities in Belgium, a novel tool is required, able to integrate the three underlying dimensions, and adapted to the local context.**

Problem statement

In Belgium, there is currently no systematic monitoring of environmental health inequalities, nor are there tailored tools to assess the impact of policy measures on the extent of and inequalities in environmental burden of disease. In part, this situation is the result of both the important data needs and the methodological challenges in developing such a system.

[Objectives]

The overall objectives of ELLIS will be to develop tools to a) monitor the extent of socioeconomic differences in environmental burden of disease; and b) assess the impact of policy measures on environmental health inequalities.

To achieve this goal, ELLIS will integrate the three dimensions of environmental health inequalities – i.e., socioeconomic deprivation, environmental exposures, and health outcomes. To increase flexibility and sustainability, the integration of these dimensions will take place at the level of the statistical sector (i.e., the smallest administrative subdivision of Belgium). In addition to monitoring the situation, ELLIS will allow simulating the potential impact of alternative policy scenarios on the extent of and inequalities in environmental burden of disease. Throughout the course of the project, stakeholders will be pro-actively involved in order to identify the most appropriate scenarios and to facilitate knowledge transfer.

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