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The Haves, the Have-Nots, and the Health of Everyone: The Relationship Between Social Inequality and Environmental Quality

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income inequality, segregation, environmental justice, environmental health disparities, ecological economics

Abstract

A growing body of literature suggests that more unequal societies have more polluted and degraded environments, perhaps helping explain why more unequal societies are often less healthy. We summarize the mechanisms by which inequality can lead to environmental degradation and their relevance for public health. We review the evidence of a relationship between environmental quality and social inequality along the axes of income, wealth, political power, and race and ethnicity. Our review suggests that the evidence is strongest for air- and water-quality measures that have more immediate health implications; evidence is less strong for more dispersed pollutants that have longer-term health impacts. More attention should be paid in research and in practice to links among inequality, the environment, and health, including more within-country studies that may elucidate causal pathways and points of intervention. We synthesize common metrics of inequality and methodological considerations in an effort to bring cohesion to such efforts.

INTRODUCTION

SO_2: sulfur dioxide

Economic inequality has been growing steadily during the past three decades (63), with the degree of inequality and its rate of increase in the United States outpacing those in many other countries (3, 64, 71). Worrisome for many reasons, this trend has important implications for population health because of the growing evidence of an adverse effect of income inequality on measures such as self-rated health and mortality (47, 83, 95). Although the evidence is by no means unequivocal (54), in many studies inequality appears to have a spillover or contextual effect on population health above and beyond the direct impacts of impoverishment on the health of the poor. That is, although inequality disproportionately impacts the health of the most disadvantaged members of society, it also appears to be harmful for everyone. The contextual effect of inequality has been attributed to psychosocial stress resulting from perceptions of relative disadvantage (94) and the erosion of social cohesion or social capital, including divestment in public goods (42, 43).

In parallel, a separate literature suggests that unequal societies are more likely to pollute or otherwise degrade their environments. We refer to this as the equality/sustainability hypothesis. Again, the findings suggest a contextual effect by which inequality not only leads to disparities in environmental exposures that disproportionately burden the disadvantaged (59), but also leads to higher overall levels of exposure to health-damaging pollutants for everyone. For example, in some countries, inequality in income or political power appears to be associated with higher concentrations of sulfur dioxide (SO_2) (21, 88), and in the United States, ambient concentrations of SO_2 rise in metropolitan areas in parallel with the degree of residential segregation by race (61). Since SO_2 is a known cause of respiratory illness, it follows that an additional pathway through which social inequality may worsen population health is via a less healthful environment. This hypothesis is supported by recent evidence that the severity of air and water pollution appears to explain some of the observed association found in cross-country comparisons between income inequality and the survival rate of children younger than 5 years (17).

We review the literature linking social inequality and environmental quality with an emphasis on aspects of environmental quality of most relevance for public health. Although the work on inequality and health has focused on income inequality, we employ a broader definition that encompasses additional forms of economic inequality (e.g., landholdings), inequality in political power (often operationalized using measures of democratic freedoms), and racial or ethnic inequalities (exhibited in disparities in environmental exposures and residential segregation). We begin by describing the mechanisms by which social inequality may affect environmental quality, and then assess the relative strength of the evidence regarding different environmental outcomes. We conclude by outlining the implications of this work for future research and policy making.

THEORIES LINKING INEQUALITY AND THE ENVIRONMENT

How might social inequality negatively impact the environment? Proposed hypotheses fall into three broad categories:

1. effects arising from inequalities in political power that determine whose interests are represented in social decision-making processes,
2. effects mediated by a relationship between inequality and the environmental intensity of consumption, and
3. effects mediated by social cohesion and cooperation to protect common resources.

We summarize these schematically in **Figure 1**.

It is important to clarify that these explanations—as for those linking inequality and health (15)—are thought to produce a contextual effect above and beyond the aggregation of individual or

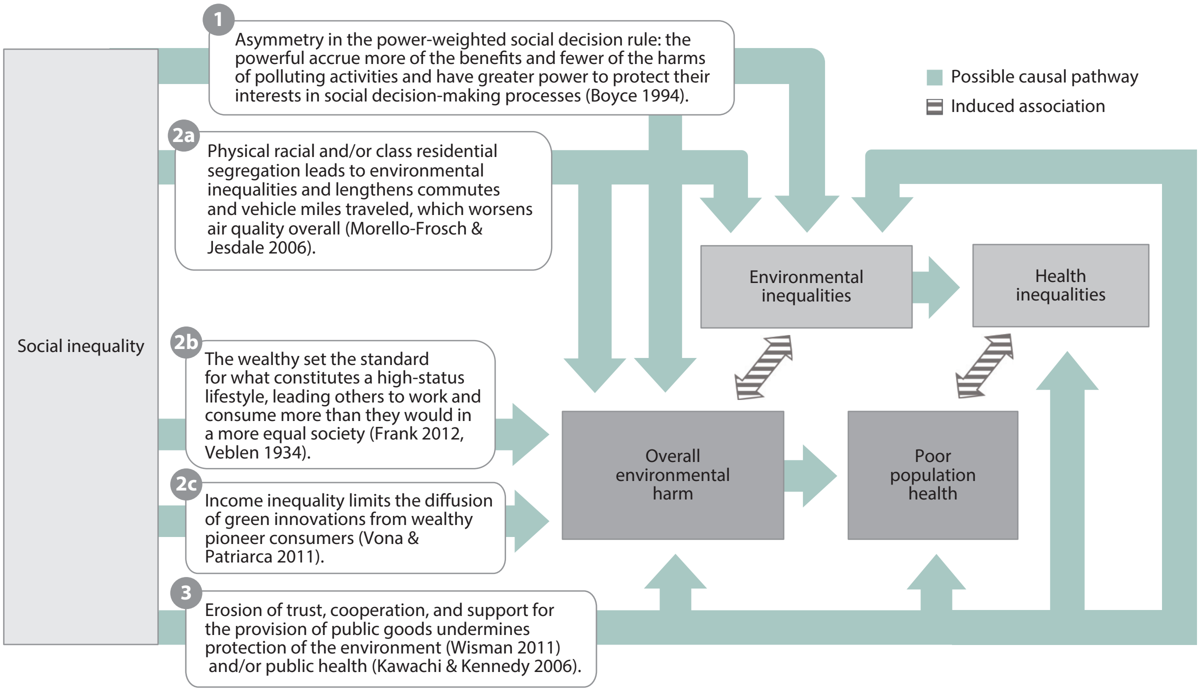

Figure 1

Explanations for a contextual or spillover effect of social inequality on the environment relate to (1) asymmetries in political power, (2) the relationship between inequality and the environmental intensity of consumption, and (3) the erosion of social cohesion and cooperation.

household-level effects. That is, they seek to explain whether there is an impact on the environment associated with living in an unequal society in addition to any effects of there simply being more rich (or privileged) or more poor (or disadvantaged) people, or both. For example, this would be relevant if there is a nonlinear relationship between a household's environmental impact and its income. Suppose that as incomes rise, households initially increase their environmental impact as they increase their use of environmentally damaging goods and services. As they acquire more disposable income, they are better able to exercise their preferences for a clean environment by purchasing more efficient technologies or investing in pollution control, which may offset the impact of their increased consumption. This leads to an inverted U-shaped relationship between household income and environmental harm [a scenario—albeit hotly contested (82)—that has been highlighted by scholarship on the household-level environmental Kuznets curve (41)]. In this case, aggregating the household-level effects of heightened income inequality that are brought about by an increase in the number of poor or wealthy households, or both—which essentially tug households away from the higher-polluting middle of the inverted U-shape—would result in an improvement in environmental quality. Although we do not discuss the literature on the relationship between household-level income and the environment, or enter into a debate about the validity of the household-level environmental Kuznets curve, it is important to be cognizant of such possible effects because, as others have noted, aggregated individual-level effects can either cancel out or heighten the contextual effect of inequality on environmental quality, depending on the underlying relationship between income and environmental impact (32).

The Power-Weighted Social Decision Rule

One hypothesis about the relationship between equality and sustainability posits that asymmetry in political power between the wealthy and the poor results in greater levels of pollution (7). In this view, the wealthy accrue more of the economic benefits of polluting activities as both producers (e.g., shareholders of polluting industries) and consumers (because consumption increases with wealth), even as they are better able to avoid the harmful effects of pollution—for example, by moving away from industrial areas or wielding political influence to keep polluting activities from being sited in their neighborhoods. When wealth translates into political power, this economic interest in polluting the environment is protected by policy decisions, such as by failing to adopt strong environmental regulations.

Political power may be asymmetrical along racial or ethnic lines as well as along economic ones. Differences in political power may help explain disparities in exposures to environmental hazards, which in the United States are generally stronger in relation to race and ethnicity than in relation to income or class (74). The power-weighted social decision rule suggests that inequality in environmental exposures that disproportionately burden less politically powerful segments of society—including racial and ethnic minorities—may result in higher overall levels of pollution. Causality may run in either direction: when pollution can be easily displaced onto disadvantaged communities because they have limited political power, industry may be encouraged to pollute more. At the same time, in more polluted areas, politically powerful residents are likely to invest more of their political capital into influencing decisions about where undesirable land uses are sited in ways that benefit them, leading to deeper inequalities in exposure (2).

Conversely, Olson (65) argues that when wealthy individuals accrue most of the benefits of a collective good, such as environmental protection, inequality can promote conservation by increasing the likelihood that a few wealthy individuals will be willing to pay for that good regardless of the actions of others. For example, the US conservation movement of the late eighteenth and early nineteenth centuries achieved the creation of new parklands in the Adirondacks largely because wealthy recreational sportsmen and industrialists were interested in preserving downstream water resources for mills and canals (35). However, resource enclosures benefiting the politically powerful that are accomplished via "coercive conservation" often do not succeed in protecting the environment and can adversely affect the well-being and livelihoods of marginalized groups (56, 70). For example, some land-conservation efforts financed through tourism have led to the construction of infrastructure in natural areas that may do more harm than good to ecosystems while also cutting off access for local users (18).

Inequality and the Environmental Intensity of Consumption

Veblen (92) and Frank (23) argue that inequality leads people to consume more because of a desire to emulate the wealthy. When the consumption levels of the wealthiest set the standard for what constitutes a good life and when society is highly unequal, consumers must stretch further to meet that standard by earning and spending more. This may explain why the recent growth in income inequality in the United States—facilitated by the increased availability of credit—has been accompanied by rising household debt across the entire income spectrum as well as by longer work hours (23, 96). Further support for this hypothesis comes from a comparison of relatively wealthy countries that found a 1.8–3.4% increase in annual work hours per change in standard deviation in the inequality of earnings (6).

Increases in work hours, in turn, result in greater stresses on the environment because (*a*) they increase overall economic production, a primary driver of environmental degradation, and (*b*) longer work hours are thought to induce changes in the environmental intensity of lifestyles. Time scarcity can lead individuals to make choices that are less environmentally sound, such as driving rather than taking public transit or biking, or hiring a domestic worker who must commute across town for work (14, 37). Cross-country comparisons suggest that longer work hours are associated with a larger national, ecological footprint, a measure of the consumption-based use of natural resources, through both pathways (31, 46).

Additionally, as income inequality rises, the economic elite often increasingly isolate themselves from larger society in gated communities, exclusive clubs, and private schools (50). The physical separation between relatively privileged members of society and those who are disadvantaged that may be enacted via residential segregation by race and class may lead to longer commutes. For example, white flight to new suburban developments in the United States during the 1950s and 1960s increased the average distance people had to travel for work (20). Segregation might thereby increase vehicular emissions associated with commuting, which could help explain the observed association between residential segregation by race and increased air pollutants across US metropolitan areas (60).

Finally, Vona & Patriarca (93) have shown that income inequality limits the diffusion of green innovations, particularly in rich countries. Because new energy-efficient products such as electric cars are expensive when they first enter the market, wealthy consumers provide the initial demand to support their further development. As the market share of these products grows and the industry matures, prices decrease, enabling more consumers to purchase the good. However, income inequality can undermine this transition by widening the price gap between what wealthy and middle-class households can afford.

Social Cohesion and Cooperation

Social cohesion in the form of trust and cooperation is also thought to promote collective environmental stewardship of common-pool resources, a hypothesis analogous to the research on health and social capital (44) and its relationship to income inequality (43). This theory posits that generalized trust among strangers arises from egalitarian moral norms learned early in life through the processes of socialization (62, 90). Social inequality erodes trust (13, 45) by increasing competition and insecurity about the future, leading individuals to fear each other as rivals (89) and making cooperation appear more risky. These trends may erode investments in public services, such as education and public transit that can help lessen a society's impact on the environment (96).

The idea that trust and cooperation are necessary to overcome the barriers to taking collective action to protect the environment has both theoretical and empirical support (66). For example, surveys suggest that individuals who are trusting are more likely to recycle (81), use public transportation (91), buy green products (29), and join an environmental organization (80), although effect sizes vary across cultures (34), and the reverse hypothesis—that environmentally minded individuals are more trusting—cannot be ruled out. Studies showing that unequal societies invest less in pro-environmental policies, monitoring, and research (39, 55, 85, 93) also suggest that inequality undermines the willingness to cooperate to protect the environment.

Other supportive evidence comes from agent-based modeling (38) and game-playing experiments, although in the latter case the results have been mixed and the degree to which experimental findings are generalizable to the real world is uncertain (1). In one experiment, participants were given an unequal amount of money and asked to contribute to a public fund to prevent climate change. Inequalities in wealth among the participants were found to impede collective action only when the risks of harm from climate disaster were greater for poor participants (9)—that is, only when coupled with an inequitable distribution of environmental risk did inequalities in wealth impede cooperation.

THE EVIDENCE

Spearheaded by the work of Boyce (7), the literature in ecological economics that examines the link between inequality and environmental quality has grown during the past two decades. Our summary focuses on studies of air pollutants, water quality, and emissions of toxic chemicals because of their direct relevance to public health. Other studies linking inequality with higher rates of biodiversity loss (33, 58; see 68 for evidence to the contrary) and deforestation (32, 48, 79) have indirect implications for health and are therefore not covered here.

International Studies

Cross-country comparisons of social inequality and environmental quality have considered air- and water-quality outcomes using data on national emissions of pollutants and ambient concentrations that have been collected from monitoring networks. One of the earliest studies examined seven measures of environmental quality using data obtained from the United Nation's Global Environment Monitoring System: average urban concentrations of SO_2, smoke, and heavy particles in the air; dissolved oxygen and fecal coliform bacteria in water; and estimates of the percentage of the population that had access to safe water and sanitation (88). In the study, Torras & Boyce (88) characterized inequality using the Gini coefficient of income inequality, the literacy rate, and qualitative indices of political rights and civil liberties developed by Freedom House (22). The political rights index produced the most consistent findings, suggesting that inequality worsens both air and water quality, especially in low-income countries (i.e., with per capita incomes of less than $5,000 when adjusted for purchasing power parity), although the researchers also found evidence contradicting the equality/sustainability hypothesis under certain circumstances (e.g., income inequality was associated with lower SO_2 and fecal coliform levels in high-income countries). Utilizing the same data sources as Torras & Boyce, Scruggs (77) found that political inequality was associated with higher ambient concentrations of SO_2. However, Scruggs also found that income inequality was associated with less ambient particulate matter and, in a separate analysis limited to 17 industrialized democracies, found an association—albeit weak—between income inequality and improvements in a composite measure of environmental quality.

Subsequent cross-sectional studies have reported largely contradictory findings regarding the association between inequality and air quality. Lamla (49) did not find strong support for an association between SO_2 emissions and inequality in wages in the manufacturing sector (measured using Theil's T statistic). The authors found moderate support for an association among greater political rights and civil liberties (again measured using the Freedom House indices), and higher SO_2 emissions, contradicting the equality/sustainability hypothesis. In a cross-sectional study of 54 diverse countries, Grafton & Knowles (27) considered the relationship among several measures of social capital and divergence, and six measures of environmental quality. Inequalities in wealth (measured using the Gini coefficient of landholdings) were associated with reduced SO_2 concentrations and improved water quality, but also with reductions in a composite index of environmental quality that encompassed air quality, water quality and quantity, biodiversity, and other variables. This latter association was greater in countries with higher per capita incomes.

More recently, scholars have taken advantage of the availability of longer time series data on air quality, and utilized longitudinal study designs with panel data. These studies largely support the equality/sustainability hypothesis, particularly in regards to inequality in political power. Barrett & Graddy (4) found a monotonic decrease in levels of ambient SO_2, smoke, and particulates as political rights and civil liberties increased (measured using the Freedom House indices) across their sample of 22–47 countries. Clement & Meunie (11) also found that equalities in power (measured using a Freedom House index) were associated with lower SO_2 emissions across 83 countries with developing or transitioning economies, but the Gini coefficient of income inequality had no apparent relationship with SO_2 emissions. Harbaugh et al. (30) corroborated the link between more equality in political power and reductions in ambient air pollution. Their study of levels of SO_2, smoke, and total suspended particulates utilized the Polity III index of democracy, which combines indicators of regime type and political regulation and is highly correlated with the Freedom House indices used by other researchers to characterize inequalities in power (36). Bernauer & Koubi (5) also found that more democratic freedoms (as measured using the Polity index, a Freedom House index, and the size of the winning coalition over the selectorate) were associated with reduced ambient concentrations of SO_2.

CO_2: carbon dioxide

Farzin & Bond (21) found that income inequality was associated with higher SO_2 concentrations and, only in high-income countries, it was associated with higher emissions of nonmethane volatile organic compounds and SO_2. In a separate analysis, higher levels of democracy (measured using the Polity IV index) were associated with decreased emissions of these same pollutants as well as with decreases in emissions of nitrous oxides (NO_x), except in low-income countries (i.e., with a gross domestic product, or GDP, at less than the 25th percentile). Another longitudinal study compared 90 developed and developing countries and found that income inequality was associated with higher emissions of SO_2 per economic output (GDP) only in developing countries (17). Inequality in income was also associated with a lower survival rate of children younger than five years, and this shrunk slightly when SO_2 or water quality was included in the model, suggesting that part of the inequality effect on health was mediated by worsened environmental quality. However, Qu & Zhang (72) found little evidence of an association between the Gini coefficient of income inequality and per capita emissions of SO_2 or NO_x in their study of 36 middle- and high-income countries.

Other work on air quality has considered emissions of carbon dioxide (CO_2), a primary driver of climate change. Although climate change will clearly impact public health, we omit lengthy discussion of these studies because CO_2 itself has little direct health impact in the communities where the emissions occur. Several international studies of CO_2 emissions have suggested that, contrary to the equality/sustainability hypothesis, income inequality is associated with reduced emissions (26, 32, 73), although this is not universally the case (12, 17, 21, 28).

Studies of water quality have utilized ambient monitoring of fecal coliform and chemical contaminants in water; markers of organic water pollution, such as biological oxygen demand and dissolved oxygen; and estimates of the percentage of the population that has access to safe water and sanitation. In addition to the work of Torras & Boyce (88) and Grafton & Knowles (27) described above, Scruggs (77) found that income inequality was associated with worse water quality (that is, with less dissolved oxygen and more fecal coliform, although the latter was not statistically significant); however, Barrett & Graddy (4) found that increased democratic freedoms (measured using the Freedom House indices) were associated with lower concentrations of fecal coliform and arsenic in rivers, but this did not seem to affect their oxygen regimes. In contrast, a longitudinal analysis of 120 countries by Gassebner et al. (26) concluded that income inequality had a beneficial association with water quality (as measured by a lower biological demand for oxygen). Clement & Meunie (11) also found that income inequality was associated with a lower biological demand for oxygen in countries with transitioning economies, whereas it had the opposite association in developing economies, depending on the polity.

Torras (86) examined 180 countries and found that higher levels of educational attainment and literacy—two measures he considered proxies for power equality—were associated with better access to safe water, sanitation, or both. Other measures, including the Gini coefficient of income inequality, the Freedom House indices, female representation in government, and the prevalence of Internet access, did not exhibit statistically significant relationships with either access to water or sanitation. A subsequent study, in which these measures were combined using principal component analysis, found a positive association between power equality and access to safe water and sanitation as well as disability-adjusted life expectancy and child mortality (87). Similarly, in a cross-sectional analysis of a smaller, diverse set of countries, Heerink et al. (32) found that access to safe water and sanitation declined as inequalities in income increased.

TRI: Toxics Release Inventory

Finally, two studies have considered the lead content of gasoline. Fredriksson et al. (24) examined 82 developing and 22 developed countries and found that increased political participation (measured as the percentage of the total population that voted in elections) was associated with lower lead content in gasoline, but only when the country exhibited adequate political competition (measured as the percentage of votes won by all but the largest political party). But in a comparison of 48 countries, Gassebner et al. (25) found that higher income inequality was associated with a lower lead content in gasoline. The authors hypothesized that a common cause—the deindustrialization of economies—simultaneously reduced political opposition to environmental regulation and deepened income inequality via the loss of well-paid blue-collar jobs.

Within-Country Comparisons

The studies we reviewed that examined the equality/sustainability hypothesis within a single country came entirely from the United States. These studies have focused on the hazardous waste and pollutants regulated under the Clean Air Act of 1970 and Clean Water Act of 1972, and have used ambient measurements from monitoring networks, emissions estimates from diverse sources, as well as modeled concentrations.

Two early studies considered variations in environmental quality across US states. Templet (84) modeled industrial emissions reported to the US Environmental Protection Agency's Toxics Release Inventory (TRI) and used a composite measure (the Green Index) that incorporated more than 250 indicators of air and water pollution, pesticide use, and other measures. He developed three metrics of inequity that were combined into one index: the ratio of TRI emissions to manufacturing jobs, the ratio of energy prices charged to residential versus industrial consumers, and the ratio of state revenue from regressive (sales) versus progressive (income and property) taxes. Using a cross-sectional study design and simple bivariate statistical analyses, the author found that more equity was correlated with reductions in the total amount of toxics released and better performance on the Green Index.

Boyce et al. (8) also considered variations among US states using a composite index of environmental stress that incorporated 167 indicators of air and water pollution, toxic chemical releases, pesticide use, and other measures, as well as an index of state-level environmental policy related to these aspects of environmental quality. Utilizing a cross-sectional study design, the authors found that an index of power equality that combined voter turnout, educational attainment, tax fairness, and access to Medicaid was associated with stronger environmental policies, which were, in turn, associated with less environmental stress. The measure of power equality was inversely associated with income inequality and the percentage of minority residents in the state. In separate models, greater environmental stress and power inequality were also associated with a higher infant mortality rate and a premature death rate.

Rupasingha et al. (76) modeled per capita pounds of TRI emissions into air, water, and land from industrial facilities across US counties. Controlling for county-level per capita income, the proportion of the workforce in manufacturing, the population density, urbanicity, educational attainment, and racial and ethnic diversity, the authors found that income inequality (measured as the ratio of mean household income to median household income) exhibited an inverted U-shaped relationship with each of the environmental outcomes. Because the authors did not report the turning point or the number of counties in which inequality appeared to have a harmful versus beneficial relationship with emissions, it is difficult to evaluate the overall effect. It is also possible that the county level may be too small to fully capture the scale on which inequality operates to degrade the environment, as has been suggested for health (95).

Several studies have also considered the relationship between racial or ethnic inequalities and overall environmental quality in the United States. Morello-Frosch and Jesdale (60) considered the degree of residential segregation by race and ethnicity and its relationship to modeled ambient air toxics across US metropolitan areas. Using a multigroup dissimilarity index to characterize segregation, the authors found that as segregation increased, the estimated risks of cancer associated with ambient air toxics also increased for all racial groups. That is, segregation appeared to have a detrimental effect for everyone, with the strongest effect experienced by Hispanics. Morello-Frosch and Lopez (61) similarly showed that levels of residential segregation between blacks and whites were associated with increases in average ambient concentrations of SO_2 and ozone but with decreased levels of carbon monoxide.

Matthews (57) considered local pollution havens—defined as US counties where environmental regulation is weak and toxic emissions into the air are high per unit of economic reward in the form of manufacturing jobs and average manufacturing wages—and found that pollution havens had a higher degree of county-level dissimilarity between blacks and whites. Furthermore, Ash et al. (2) found that across US metropolitan areas, greater disparities between minorities and whites in the average health risk from modeled concentrations of air pollutants were associated with greater risks to both populations. The association was even stronger for low-income members of both the minority groups and the white group.

To our knowledge, only one study has examined an outcome related to the health risks of climate change. Jesdale et al. (40) considered the distribution of high-heat risk neighborhoods with little tree cover and a high proportion of heat-trapping impervious surfaces. Controlling for biophysical determinants of plant growth, residential segregation by race and ethnicity across US metropolitan areas was associated with more heat-trapping land cover—that is, segregation was associated with higher climate-related risks for everyone. The association was apparent for all racial and ethnic groups but was strongest for Hispanics, and appeared to be mediated by population density as well as the size of the metropolitan area.

The only longitudinal study we encountered considered estimates of national emissions of SO_2 in the United States from 1947 to 1996, a period spanning the enactment of the Clean Air Act (78). The authors suggest that the decrease in SO_2 emissions was associated with increased national-level income inequality. However, the authors did not control for other potential causes of rising inequalities in income during this period. The relationship they observed may be spurious because implementation of SO_2 regulations under the Clean Air Act coincided with the massive economic restructuring that resulted from globalization, which drove many manufacturing industries overseas.

DISCUSSION

The equality/sustainability literature considers a broad spectrum of environmental outcomes and inequality measures, and employs a wide range of theoretical models and analytical approaches, making synthesis challenging. Nevertheless, the findings of a majority of studies suggest that inequality is linked to higher burdens of air pollution, at least in some contexts. Fewer studies have examined water quality, but the findings of those that did suggest that inequality is associated with decreases in access to safe water and sanitation. The evidence regarding the oxygen regimes of rivers—a marker of water pollution that has more immediate consequences for aquatic life than for human life—and emissions of CO_2—which have more dispersed and long-term health impacts—is mixed. This suggests that localized health effects, whether perceived or realized, may play a part in determining the direction and magnitude of the net effect of social inequality on environmental quality. Differences in findings may be accounted for by differences in study designs; measures of inequality; geographical scale; model specifications, including the addition of fixed country effects, lagged effects, interactions, and nonlinear terms; and controls for geographical features of sampling locations.

Measuring Inequality and its Effects

Although the literature has employed a wide variety of measures to capture multiple dimensions of social inequality (**Table 1**), the choice of metric is often limited by the availability of high-quality comparable data, particularly in the international context. This is a drawback because different metrics of inequality have different strengths and weaknesses, and using different metrics can lead to different conclusions about the evolution of inequality over time (19) as well as to differences in estimates of the size of effects and possibly even their direction. Future work would be strengthened if better data were available to allow researchers to consider the sensitivity of their findings in relation to the choice of inequality metric, as has been suggested with regards to research into health (51).

We have identified four additional trends in the field that have implications for future work. First, research is moving from cross-sectional to longitudinal study designs. Although this can help to confirm a causal relationship between inequality and environmental quality, inequality tends to change slowly over time. Authors conducting cross-country comparisons can, and often do, include a fixed effect for the country to control for unmeasured differences between countries that may be independently correlated with income inequality and environmental quality. However, although findings from analyses that do not consider fixed effects may suffer from residual confounding, including a fixed effect may make it difficult to estimate the effect of income inequality due to its slow rate of change.

Longitudinal studies also need to consider possible confounders that vary over time. For example, the transition from an industrial to a more service-based economy may independently cause a decrease in emissions of pollutants, as well as losses of political power and income among blue-collar workers and unions that result in greater inequality (25). Not controlling for the deindustrialization of the economy would introduce a spurious association suggesting that inequality is good for the environment. This is especially problematic because deindustrialization often leads to industries moving offshore to countries with more lax environmental regulations, so the net effect on the global environment is detrimental. Consumption-based rather than production-based metrics offer one solution to better measure environmental impacts in countries where most goods are produced abroad (75).

Second, although between-country studies dominate the literature, within-country studies provide more consistent support for the equality/sustainability hypothesis. This may be because studies looking at regions within a single country benefit from greater consistency and accuracy of data, and because the larger political and development contexts are held fixed. However, the within-country literature is small and consists of only US-based studies that are primarily cross-sectional in design. The field would benefit from intranational longitudinal studies that examine a more diverse set of countries.

Table 1 Measures of inequality that have been used in the literature on equality and sustainability

Measure	Description	Dimension measured (reference)
80/20 income ratio	Ratio of the share of income held by the top quintile compared with that held by the bottom quintile	Income inequality (77)
Coefficient of variation	A measure of dispersion relative to the mean with lower values indicating less dispersion:[a] $\frac{\sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(x_i-\bar{x})^2}}{\bar{x}}$	Income inequality (e.g., 28)
Dissimilarity index (between blacks and whites or between multiple groups)	Proportion of the subpopulation m who would need to relocate to a different neighborhood to achieve an even distribution throughout a larger (e.g., metropolitan) area:[b] $\frac{\sum(n_i\sum\|p_{im}-P_m\|)}{2N\sum P_m(1-P_m)}$	Racial and ethnic residential segregation (e.g., 60, 61)
Educational attainment	Percentage of the population aged 25 years and older that graduated from high school	Power equality (e.g., 8)
Emissions per economic benefit	Pounds of industrial emissions divided by the number of manufacturing jobs or average manufacturing wage	Environmental inequity (e.g., 57, 84)
Female representation in government	Proportion of government positions held by women	Power equality (e.g., 86)
Freedom House indices of political freedoms and civil liberties	Composite scores based on experts' evaluations of electoral processes, political pluralism and participation, the functioning of government, freedom of expression and belief, rights to associate and organize, rules of law, and personal autonomy and individual rights	Power equality (e.g., 88)
Gini coefficient	A measure of absolute differences between all pairs of individuals i and j, where 0 represents perfect equality and a value of 1 means one individual holds all resources:[a] $\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\|x_i-x_j\|}{2n^2\bar{x}}$	Inequality in income and landholdings (e.g., 27, 88)
Internet access	Share of the population with access to the Internet	Power equality (e.g., 86)
Literacy rate	Proportion of the adult population who can read	Power equality (e.g., 86, 88)
Medicaid access	Index assessing interstate differences in the United States in poor people's access to health care through the Medicaid program	Power equality (e.g., 8)
Minority discrepancy	Share of the total pollution burden borne by members of subpopulation m less their share of the total population:[c] $\frac{\sum\delta_{mi}\times C_i}{\sum\delta_i\times C_i}-P_m$	Inequality in the burden of toxic chemicals (2)
Polity III and IV indices	Composite score based on experts' evaluations of the competitiveness and regulation of political participation, the openness and competitiveness of executive recruitment, and constraints on the chief executive	Democracy (e.g., 21, 30)
Ratio of regressive to progressive tax revenue	State sales tax revenue divided by the sum of income and property tax revenues	Tax inequity (e.g., 84)
Residential to industrial energy price ratio	Energy price charged to residential customers divided by the energy price charged to industrial customers	Energy inequity (e.g., 84)
Tax fairness	Composite score including the percentage of income spent on sales and excise taxes by the poorest income quintile, the ratio of the income tax burden of the top 1% to the bottom 60% of earners, the personal income tax threshold, and an index of corporate tax policies	Power equality (e.g., 8)

(*Continued*)

Table 1 (*Continued*)

Measure	Description	Dimension measured (reference)
Theil's T statistic	A measure of entropy where 0 represents perfect equality and a value of $\ln(n)$ means one individual or group holds all resources:[a] $\frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i}{\bar{x}}\right)\ln\left(\frac{x_i}{\bar{x}}\right)$	Inequality in income or salaries (e.g., 26, 49)
Voter turnout	Proportion of eligible voters or total population who voted in a given election	Power equality (e.g., 8)
Winning coalition over the selectorate	Proportion of people who can affect the choice of leaders (known as the selectorate) who are in the subgroup of the selectorate that maintains incumbents in office (the winning coalition)	Democracy (e.g., 5)

[a] x is an observed value; n is the number of values observed; and $\bar{x}$ is the mean value.
[b] n_i is the number of residents in a neighborhood i; p_{im} is the proportion of people in subgroup m in neighborhood i; N is the total number of residents in the larger area; and P_m is the proportion of people in subgroup m in the larger area.
[c] C_i is the pollution burden in neighborhood i within a larger (e.g., metropolitan) area; δ_i is the population of neighborhood i; δ_{mi} is the population of the racial or ethnic group m in neighborhood i; and P_m is the proportion of people in subgroup m in the larger area.

Third, many international studies have observed effect modifications that depend on a country's average income, development level, or the type of government. The directions of these effects have been mixed, with some studies finding evidence supporting the equality/sustainability hypothesis only among developing countries (e.g., 88), and others supporting it only within high-income countries (e.g., 21). Nevertheless, these findings suggest the need for future work to further explore potential effect modifications associated with the larger political and development contexts of the study sites, as well as the possibility of nonlinear or threshold effects (76).

Finally, few studies have considered the spatial nature of their data, and all but one ignored the possibility that the environment or the degree of social inequality in one area may affect that of a neighboring area in a manner that may bias results. Such spatial dependence violates the assumption of independent observations inherent in the statistical methods used in most of these studies (e.g., generalized linear models). If pollution and inequality are spatially but not causally related, this may lead researchers to infer a spurious association between the two (see discussion in 69). For example, Rupasingha et al. (76) found that controlling for spatial autocorrelation significantly reduced the (negative) association they observed between income inequality and emissions of toxic chemicals in the United States. A methodological improvement in this field would be to control for spatial autocorrelation through the use of spatial models.

Implications for Research and Practice

Although the field of ecological economics has developed a robust body of literature to examine the equality/sustainability hypothesis, this line of inquiry has not been deeply explored in environmental health. Nevertheless, scientific interest in health disparities and environmental justice is beginning to catalyze more work in this area, particularly as environmental health scientists leverage methods used in social epidemiology to elucidate the pathways by which social inequality not only contributes to disparities in environmental health but degrades environmental health overall.

Although the work has begun, we need better integrated and systems-based approaches to explore the fundamental causes, mediating mechanisms, and feedback loops that influence how different forms of social inequality potentially degrade environmental quality in ways that adversely affect population health (16). Ostrom (67) advocates using a social–ecological framework to understand how systems are progressively linked to ever larger systems, and how upward and downward linkages play out within, as well as across, diverse sectors and scales. Such dynamic systems-based models can help integrate qualitative and quantitative data and facilitate input from and testing by diverse stakeholders from multiple disciplines.

Moreover, emerging evidence suggesting that social inequality is linked to worse environmental quality indicates that policies should take into account how decision making about development and land use are shaped by different forms of social inequality in ways that can have disproportionate environmental impacts on disadvantaged groups, and potentially undermine the health and well-being of everyone. Indeed, research has suggested that targeting environmental regulations to improve conditions for those who are most negatively impacted by environmental hazards can improve overall outcomes at the population level. For example, Levy et al. (53) considered both the equity and efficiency benefits of a suite of hypothetical rollouts of emissions-control technology at power plants in the United States; they found that reductions in spatial inequality in mortality associated with emissions of SO_2 and fine particulate matter correlated with higher total reductions in mortality. A later study looking at controls on tail-pipe emissions on public buses in Boston drew similar conclusions (52).

Finally, future research needs to resolve some of the methodological quandaries and shortcomings of previous work, in part because the nexus between social equity and sustainability is becoming increasingly salient, both nationally and globally. As many countries become more fragmented by class, race, and imbalances in political power (10, 71), research should track how policies aimed at leveling the economic and political playing fields may broadly benefit the health and well-being of everyone, and elucidate viable paths for achieving goals of both social equity and environmental sustainability.

SUMMARY POINTS

1. Evidence supporting the equality/sustainability hypothesis suggests that social inequality is bad for the environment, which may in turn explain why societies with more inequality appear to be less healthy.
2. Social inequality may degrade the environment through asymmetries in political power that affect who experiences the benefits and harms of pollution.
3. Social inequality may also worsen environmental quality by increasing the environmental intensity of a society's consumption or decreasing social cohesion and the willingness to cooperate to protect common resources.
4. Evidence of a negative association between social inequality and environmental quality appears strongest for localized air pollutants and markers of access to safe water and sanitation, and weaker for more dispersed pollutants, such as CO_2, and other measures of water quality.
5. The evidence linking inequality with worse environmental quality is more consistent in within-country studies from the United States than in between-country studies, perhaps because the former benefit from a greater consistency in data and the fact that the larger political and development contexts are held fixed.

6. Challenges to conducting this research include the fact that inequality changes slowly over time so that longitudinal effects are hard to estimate and the fact that nonlinear effects and effect modifiers appear to play a part.
7. Although the evidence remains somewhat mixed and more research is needed, there are intriguing indications that reducing social inequality may not only help those who are most exposed to health-damaging pollutants but may also improve environmental conditions for all.

DISCLOSURE STATEMENT

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