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Integrating Environmental Justice into Public Health: Approaches for Understanding Cumulative Impacts

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Integrating Environmental Justice into Public Health: Approaches for Understanding Cumulative Impacts

Abstract

Communities located near multiple sources of pollution, including current and former industrial sites, major roadways, and agricultural operations, are often predominantly low-income, with a large percentage of minorities and non-English speakers. These communities face additional challenges that can affect the health of their residents, including limited access to health care, a shortage of grocery stores, poor housing quality, and a lack of parks and open spaces. Research is now showing that environmental exposures can interact with social stressors, thereby worsening health outcomes. Age, nutrition, genetic characteristics, and preexisting health conditions also increase the risk of adverse health effects from exposure to pollutants. There are existing approaches for characterizing cumulative impacts, which vary in their analytical method and level of community engagement. Biomonitoring, health risk assessment, ecological risk assessment, health impact assessment, burden of disease, and cumulative impacts mapping have all been used to evaluate aspects of this issue. Although such approaches have merit, they each also have significant constraints. New developments in exposure monitoring, mapping, toxicology, and genomics, especially when informed by community participation, have the potential to advance the science on cumulative impacts and to improve prioritization, resource allocation, and risk reduction.

Keywords

CalEnviroScreen, biomonitoring, environmental justice, health impact assessment, risk assessment

Cover Page Footnote

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INTRODUCTION

Systematic disparities in disease are well-documented along socioeconomic and racial/ethnic lines.[1] Many diseases, including asthma, cardiovascular disease, adverse reproductive outcomes, and cancer, are associated with both social and environmental factors. For example, people living in poverty are more likely to live in poor quality housing that can increase exposures to cockroaches and mold, both of which increase the risk of asthma symptoms, thereby also increasing vulnerability to outdoor pollutants such as ozone and diesel exhaust. Cumulative exposures to environmental stressors against a background of vulnerability can result in heightened health impacts and disparities in life expectancy across a population.

Cumulative impacts assessment has the potential to provide an objective measure to focus and prioritize resources, assess changes over time, evaluate the incremental effect of one or more stressors against a background of other stressors, and comprehensively assess health risk. Unfortunately, quantitative assessment of cumulative impacts or risk is impractical or impossible in many real-world situations because data on interactions among environmental stressors are unavailable, information on place- and population-specific exposures is lacking, and validated models relating exposure to effect for multiple chemicals and combinations of stressors do not exist. The public health community is faced with the need to assess cumulative impacts as part of informed decision-making in the absence of sufficient information and appropriate tools to adequately do so.

CURRENT APPROACHES TO ASSESS CUMULATIVE IMPACTS

The environmental justice movement throughout the 1980s raised concerns about cumulative impacts. In response, President Clinton signed an order that required "[e]nvironmental human health analyses, whenever practicable and appropriate, [to]…identify multiple and cumulative exposures" (E.O. 12898, February 16, 1994). The U.S. Environmental Protection Agency (EPA) then defined cumulative risk as "the combined risks from aggregate exposure to multiple agents or stressors".[2] Unfortunately, data limitations make it difficult to generate a numerical estimate of risk for even a single environmental agent, let alone on a combination of multiple stressors. Default uncertainty factors are often used to account for vulnerability and variability within the population, but the adequacy of these factors for protecting against cumulative impacts is not established. Ultimately, the structure of quantitative risk assessment for environmental pollutants is tailored to addressing narrow questions involving small numbers of chemicals and stressors, not community-level risks.

Unlike health risk assessment, ecological risk assessment incorporated the concept of cumulative impacts from its inception in the 1990s. Ecological risk assessments are generally place-based and semi-quantitative or qualitative. The advantage of this approach is a broad scoping of chemical and nonchemical stressors in the ecosystem, with the opportunity to surface a full range of options for consideration. Although the application of ecological risk assessment to human communities may have potential, it has not yet been proven in practice.

Health impact assessment (HIA) was developed in the early 2000s to complement mandatory environmental impact assessments under the National Environmental Policy Act (NEPA). HIA considers impacts from environmental factors and economic, political, social, and psychological contributions, and the methodology includes extensive public input.[3] Unlike health risk assessment, HIA is mostly qualitative, sometimes limiting its use in decision making. HIAs evaluating multisource community impacts can be time-consuming and challenging to manage.

The World Health Organization's Global Burden of Disease approach uses disability-adjusted life years (DALYs) to measure disease burden across nations. The DALY combines years of life lost due to premature mortality and years of healthy life lost due to disability.[4] The DALY approach has some advantages over risk assessment in that it incorporates information on both the severity and the duration of health impacts, generates a metric that is more understandable than risk or probability, and can be compared across communities. Some environmental factors have been measured in this way, but uncertainties about attributable risk associated with many environmental diseases, and a failure of the approach to address the multifactorial nature of disease, has limited its utility. Many stressors cannot be quantified using the DALY and are ignored in these assessments, and the method typically does not include public input.

Cumulative impact maps such as the CalEnviroScreen and the Environmental Justice Screening Methodology (EJSM) have been developed in recent years by environmental agencies and community-academic partnerships.[5, 6] The uses of such maps include identifying areas of concern for environmental justice; targeting funds generated through California's greenhouse gas auctions; and identifying areas to improve land use planning and regulatory enforcement. The key to this approach is integrating geographic information systems (GIS) mapping with an analytical methodology to integrate chemical and nonchemical stressors and vulnerabilities in a semi-quantitative manner. Cumulative impact maps can have significant practical utility for public health practitioners and can provide analytical support to complement observations practitioners make in the field every day. Unfortunately, cumulative impact maps are not available for every state, and the methodology requires refinement to balance health, environmental, and socioeconomic vulnerabilities.

The methods described above have enabled significant progress toward understanding cumulative impacts to guide decision-making and policy, but each approach has limitations. Some methods are useful only for screening-level qualitative evaluations; others are constrained by a need for quantitative data. No single method is tailored to the needs of all actors and decision makers, and multiple approaches have utility.

NEW TOOLS FOR UNDERSTANDING CUMULATIVE IMPACTS

New approaches in exposure science, toxicology, and genomics may help address the need to better quantify cumulative impacts. Understanding the range of exposures to chemical, nutritional, health, and psychosocial stressors, and how they combine to increase health risk at the community scale requires entirely new tools and technologies.

In the field of exposure science, new sensor technologies offer the promise of highly portable distributed monitors that can capture multiple human microenvironments in an integrated exposure assessment. Such monitoring data can be supplemented with cell phone location information and video to gather extensive information about environmental exposures. Some new sensors offer real-time exposure reporting, whereas others can sample for many chemicals at once.

Other advances in exposure science, such as non-targeted and semi-targeted biomonitoring for chemicals and metabolic effects, remove the constraint of selecting test chemicals and metabolites *a priori* and can identify novel compounds for assessment and prioritization. Place-based biomonitoring with community engagement may be combined with exposure sensor technologies to develop geospatial cumulative exposure profiles. Mapping tools can also highlight areas of concern where targeted exposure studies might be warranted.

Improved understanding of the genomic, endocrine, and cell-signaling pathways involved in disease is being used to screen thousands of chemicals for potential toxicity in programs such as EPA's ToxCast (https://www.epa.gov/chemical-research/toxicity-forecasting). Such methods may identify multiple chemicals that interact with pathways relevant to a disease of interest, potentially informing cumulative risk estimates. Cell-based systems also make it feasible to screen mixtures of chemicals, to assist in the quantitative assessment of the combined biological effect of mixtures.

The cumulative degradation of physiologic systems from chronic exposure to endogenous and exogenous stressors is often called the allostatic load. Allostatic load is currently estimated through non-specific biomarkers such as cortisol, inflammatory, metabolic, and cardiovascular responses.[7] Chromosomal telomere length is a promising and potentially more specific biomarker of chronic stress response. The epigenetic modifications of chromosomes that regulate gene expression are also now measurable in people, and are known to be altered by a variety of environmental stressors. Eventually it may be possible to identify epigenetic patterns across different populations or communities to develop markers for those that face greater cumulative impacts.[8]

IMPLICATIONS

The use of cumulative impact methods increases the likelihood that disadvantaged neighborhoods may receive critical attention to improve existing conditions, reduce future harm and ultimately narrow environmental health disparities across racial and class lines. In the near term, evaluating the combined toxicity of some chemical mixtures could help demonstrate how interactive effects can occur. This information could help assess whether current default safety factors used to derive risk-based standards for pollutants are sufficient to protect socially vulnerable populations. This information could then be used to make improvements in assessment practices and decision-making to protect these groups.

SUMMARY BOX

What is already known on this topic? Chemical pollutants, social stressors, and health vulnerabilities interactively contribute to adverse public health outcomes in disadvantaged communities.

What is added by this report? This report describes existing and emerging methods to assess cumulative impacts in communities, and describes the strengths and limitations of each method.

What are the implications for public health practice/policy/research? Public health professionals and decision-makers will be able to select appropriate existing methods, or adopt emerging methods, to better prioritize resources, evaluate changes over time, identify the contribution of one or more stressors against a background of other stressors, and inform risk reduction measures.

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