Chapter 10

Environmental Justice and Life Stage Considerations

An evaluation of the impacts of a regulation on firms, workers and households is an important complement to benefit-cost analysis (BCA). Instead of focusing on quantifying and monetizing total benefits and costs, this type of analysis examines how a regulation allocates benefits, costs, transfers and other outcomes across specific groups of interest. Chapter 9 describes approaches to quantify economic impacts across a wide array of groups that may be of interest to decisionmakers. This chapter overlaps with Chapter 9 in some respects — many of the economic impact categories it discusses are also potentially relevant here — but it is distinct in several ways. First, this chapter specifically considers the possible impacts of a regulatory action on minority populations, low-income populations, or indigenous peoples (i.e., the focus of environmental justice) and on children and older adults (i.e., life stages) due to their increased vulnerability to health effects from pollution. Second, while variation in the benefits and costs of regulation across these population groups is a significant consideration, this chapter also discusses the importance of characterizing changes in human health endpoints and environmental risk.

10.1 Executive Orders, Directives and Policies

Consideration of how economic and human health effects vary across specific population groups and life stages arises from several executive orders (EOs), directives and other documents.[1,2] The Agency also has developed separate guidance to provide direction to analysts on conducting environmental justice analyses. Together these orders, directives and policies provide a solid foundation for considering effects on population groups from an environmental justice (EJ) and life stage standpoint in the rulemaking process.

In addition to the general guidance in the Office of Management and Budget's (OMB's) Circular A-4 (OMB 2003) regarding "a separate description of how both benefits and costs are distributed among populations of particular concern," the following EOs, described more fully in Chapter 2, directly address different types of effects for population groups of concern:

1 EPA's Regulatory Management Division's Action Development Process Library (http://intranet.epa.gov/adplibrary/adp) is a resource for accessing relevant statutes, executive orders and EPA policy and guidance documents in their entirety (accessed on January 11, 2021).

2 Some environmental statutes also identify population groups that may merit additional consideration. See Plan EJ 2014 Legal Tools (U.S. EPA 2011a) for a review of legal authorities under the environmental and administrative statutes administered by the EPA.

- EO 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (1994),[3] calls on each federal agency to make achieving EJ part of its mission "by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations."[4]
- EO 13045, "Protection of Children from Environmental Health Risks and Safety Risks" (1997), states that each federal agency shall ensure that its policies, programs, activities and standards address disproportionate risks to children that result from environmental health or safety risks.[5]
- EO 13175, "Consultation and Coordination with Indian Tribal Governments" (2000), calls on federal agencies to have "an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications."

Table 10.1 - Orders and Directives Relevant for Analysis of Effects on Population Groups of Concern

Dimension	Executive Order or Directive	Examples of Population Groups of Concern
Income	EO 12898; OMB Circular A-4	Low-income groups, poverty status
Race/ethnicity	EO 12898; OMB Circular A-4	Minority groups
Age	EO 13045	Children, older adults
Sex (biological)	OMB Circular A-4	Male, female
Tribes	EO 13175	Indian Tribal governments

- EO 12866, "Regulatory Planning and Review" (1993), explicitly allows for consideration of "distributive impacts" and "equity" when choosing among alternative regulatory approaches, unless prohibited by statute.[6]

3 This chapter addresses analytical components of EO 12898 and does not cover other components such as ensuring proper outreach and meaningful involvement.

4 A presidential memorandum to heads of departments and agencies that accompanied EO 12898 specifically raised the importance of procedures under the National Environmental Policy Act (NEPA) for identifying and addressing environmental justice concerns (White House 1994). The Council on Environmental Quality (CEQ) issued EJ guidance for NEPA in 1997 (CEQ 1997). The EPA issued guidance in 1998 for incorporating EJ goals into the EPA's preparation of environmental impact statements and environmental assessments under NEPA (U.S. EPA 1998a). The Presidential memorandum also states that existing civil rights statutes provide opportunities to address environmental hazards in minority communities and low-income communities (White House 1994).

5 A "covered regulatory action" under EO 13045 is any substantive action in a rulemaking that may be economically significant (i.e., have an annual effect on the economy of $100 million or more or would adversely affect in a material way the economy, a sector of the economy or the environment) and concern an environmental health risk that an agency has reason to believe may disproportionately affect children.

6 EO 13563, issued in January 2011, supplements and reaffirms the provisions of EO 12866.

Table 10.1 summarizes the relevant dimensions identified by these orders and directives and offers examples of potentially affected population groups of concern.

The U.S. Environmental Protection Agency (EPA) also has developed guidance for conducting environmental justice analysis for rulemakings, starting with the Guidance on Considering Environmental Justice During the Development of Regulatory Actions (U.S. EPA 2015). This guide is designed to help EPA staff incorporate EJ into the rulemaking process, from inception through promulgation and implementation. The guide also provides information on how to screen for EJ effects and directs rule-writers to respond to three basic questions throughout the rulemaking process:

1. How did the public participation process provide transparency and meaningful participation for minority populations, low-income populations, tribes and indigenous peoples?
2. How did the rule-writers identify and address existing and/or new disproportionate environmental and public health impacts on minority populations, low-income populations and/or indigenous peoples?
3. How did actions taken under #1 and #2 impact the outcome or final decision?

In addition, the *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* (EJTG) (U.S. EPA 2016c) provides detailed guidance on how to incorporate EJ into all aspects of the regulatory analytical process, including risk assessment and economic analysis. While the material discussed in this chapter is generally consistent with the EJTG, the EJTG includes a detailed discussion of ways to incorporate EJ into risk assessment, while this chapter is limited to how to consider EJ in economic analysis.[7]

The EJTG suggests analysts attempt to answer three questions:

1. Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern in the baseline?[8]
2. Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern for the regulatory option(s) under consideration?
3. For the regulatory option(s) under consideration, are potential EJ concerns created or mitigated compared to the baseline?

When data are available to assess both the baseline and policy options under consideration, responses to these questions provide a robust assessment of potential adverse impacts for population groups of concern. The extent to which an analysis can address all three questions will vary due to data limitations, time and resource constraints, and other technical challenges. Analysts are encouraged to document the key reasons why a specific question cannot be addressed. This will help identify future priorities for filling key data and research gaps. In addition, due to the inherent limitations and uncertainties associated with analyses of potential EJ concerns, it is important to conduct sensitivity analysis around key assumptions.

7 The economic analysis often incorporates risk assessments and analyses of risks changes associated with regulatory options. As with many aspects of the analysis, economists and risk assessors need to coordinate when conducting analyses of EJ issues.

8 Note that the term environmental stressor encompasses the range of chemical, physical, or biological agents, contaminants or pollutants that may be subject to a regulatory action.

10.2 Environmental Justice

The EPA defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (U.S. EPA 2015). EO 12898 specifically states that federal agencies should "[...] identify and address [...] disproportionately high and adverse human health or other environmental effects [...] on minority populations and low-income populations [...]" (U.S. EPA 2015).

The case is often made that there are no relevant EJ concerns for a rule that is strengthening an environmental standard. After all, environmental quality is improving. However, it is incorrect to conclude that tighter standards necessarily improve environmental quality for everyone. The nuances of a rule could change the distribution of emissions across communities. For example, a regulation that grandfathers older, more polluting facilities and allows them to continue to operate without upgrading equipment to avoid being subject to new emission requirements would mean that emissions would not fall by as much and could even increase in nearby communities.[9] In addition, while there may be few adverse environmental effects, other economic impacts (e.g., the incidence of costs) could affect population groups of concern disproportionately and may warrant examination. Finally, there may be some regulatory options that address EJ concerns more effectively than others by mitigating existing disparities or implementing the standard differently, even when all options improve overall environmental quality.

Analysis of potential EJ concerns also improves the transparency of a rulemaking and provides decision makers and the public with more complete information about a given policy's potential effects. Analysts play a role in ensuring meaningful involvement by evaluating possible differences in opportunities for ongoing public input and feedback across the regulatory options under consideration, including the ability to identify non-compliance issues or ways in which implementation may be improved once a regulation is in place. In addition, analysts can enhance meaningful involvement by explaining the analysis in plain language, including key assumptions, methods, and results, and by asking for information from the public (e.g., asking for comment in the proposed rulemaking) on exposure pathways, end points of concern and data sources that may improve the analysis.[10,11] Such documentation helps the EPA and the public track and measure progress in addressing EJ concerns. Further guidance on ensuring meaningful engagement of environmental justice stakeholders in the rulemaking process can be found in U.S. EPA (2015).

10.2.1 Background Literature

This section provides a brief overview of EJ analysis from the economics and health literatures. Studies of EJ can vary by pollutant, the proxy used for risk or exposure, geographic area and time period. In addition, studies vary in the extent to which they mainly characterize baseline conditions or attempt to examine changes in environmental exposure or risk, making it difficult to directly apply general findings to a specific rulemaking. The studies described in this section identify possible methods for evaluating EJ impacts,

9 U.S. EPA (2015) provides additional information on how an EJ concern may arise in the context of a rule.

10 Meaningful involvement occurs when "1) potentially affected populations have an appropriate opportunity to participate in decisions about a proposed activity (I.e., rulemaking) that may affect their environment and/or health; 2) the population's contribution can influence the EPA's rulemaking decisions; 3) the concerns of all participants involved will be considered in the decision-making process; and 4) the EPA will seek out and facilitate the involvement of populations potentially affected by the EPA's rulemaking process" (U.S. EPA 2015).

11 EO 13166, "Improving Access to Services for Persons with Limited English Proficiency" (2000), may also be relevant when addressing meaningful involvement. EPA's Order 1000.32 "Compliance with Executive Order 13166: Improving Access to Services for Persons with Limited English Proficiency" (LEP) requires that the EPA ensure its programs and activities are meaningfully accessible to LEP persons.

indicate contexts where EJ concerns may be present and illuminate some challenges in conducting EJ analyses such as data availability and sensitivity of results to assumptions and comparison groups. For a more comprehensive discussion, see Ringquist (2005), Banzhaf (2012a), and Banzhaf (2012b).[12,13]

It is common for EJ studies to ask whether greater amounts of pollution result in increased exposure or poorer health outcomes for certain population groups. However, there is also the possibility that some populations (e.g., children) are more susceptible to pollution for a given level of exposure and that socioeconomic factors may play a role (e.g., poorer households may have less access to health care).[14] While studies that examine differences in susceptibility across population groups are not discussed here, Section 10.2.8.5 describes various risk considerations potentially relevant to an EJ analysis, including susceptibility (also see U.S. EPA 2016c). In addition, both the EJ literature and this chapter tend to focus on how a regulatory action affects the distribution of exposure or proximity to harm, and not risk per se (e.g., an increase in the frequency or severity of health effects).[15]

Evidence exists of potential disproportionate impacts from environmental stressors on various population groups using a wide variety of proxies for exposure, many of which are proximity-based (e.g., distance to a polluting facility as a surrogate for exposure). These studies often find evidence that locally-unwanted land uses — such as landfills or facilities that treat, store or dispose of hazardous waste — are more likely to be concentrated in predominantly minority or low-income neighborhoods (for example, Bullard 1983; GAO 1983; UCC 1987; Boer et al. 1997; and Mohai et al. 2009).[16]

Other studies attempt to better approximate exposure by examining whether existing emission patterns are related to socioeconomic characteristics. These studies often focus on a specific pollutant and geographic area. They also often differ in how they define the relevant neighborhood and comparison group.[17] As such, findings with regards to whether race and income are associated with potential exposure vary across studies. For example, after controlling for other factors, Arora and Cason (1998) find that both the percentage of minority and poor households in a community are positively related to reported Toxic Release Inventory (TRI) emissions, although the significance of these relationships varies by region. Gray and Shadbegian (2004) find that communities with a higher percentage of poor households are exposed to more air and water pollution from pulp and paper mills on average, while communities with a greater percentage of minority households are exposed to less pollution on average. Some studies attempt to examine how changes in exposure or risk associate with race and income. For instance, Hamilton (1993, 1995) finds that expansion decisions for waste sites are unrelated to race and finds mixed evidence for income, while De

12 For a discussion of the possible distributional effects of environmental policies by income (but not race or ethnicity), see Fullerton (2009).

13 The impacts of environmental regulations on economic growth, productivity, firm profitability, plant closures and workers has been of keen interest to policymakers since the inception of the U.S. EPA (Ferris et al. 2017). The rise in concern over EJ is often traced to demonstrations in Warren County, North Carolina in 1982 over the siting of a polychlorinated biphenyl landfill in a poor and minority community. Public attention on these issues gradually led to an increased focus in the economics literature on burdens faced by populations of concern on the basis of race, poverty and income.

14 Individuals who are susceptible are more responsive to exposure or have an increased likelihood of adverse effects (U.S. EPA 2003b; Schwartz et al. 2011).

15 Differences in exposures or health effects alone may not be representative of differences in total benefits and costs. As discussed in Serret and Johnstone (2006) and Fullerton (2011), the full distributional effects of environmental policy could include differences in product prices, wage rates, employment effects, economic rents, etc. These impact categories are discussed in Chapter 9.

16 Others note the strength of this contemporaneous relationship but find that the direction and magnitude of the relationship between location and race or income at time of siting is less clear (e.g., Been 1994; Been and Gupta 1997; Wolverton 2009). See Shadbegian and Wolverton (2010) for a summary of the literature on firm location and environmental justice, including a discussion of whether plant location precedes changes in socioeconomic composition that result in higher percentages of non-white and poor households nearby or vice versa. Most of these studies examine partial correlations between pollution and household characteristics, using statistical techniques that control for other factors.

17 A common empirical challenge in this literature is the possibility of sorting (i.e., poorer households may move to neighborhoods with higher levels of pollution). Many studies use demographic data that precedes siting or emissions decision to control for the possibility of reverse causation. Gray and Shadbegian (2004) use a spatially-lagged instrumental variable approach because they lack demographic information that precedes plant siting.

Silva et al. (2016) find that new plants that report to the TRI are more likely to locate in census tracts with a higher share of non-white persons and persons with fewer completed years of schooling. New plants that are non-TRI reporters are less likely to locate in these neighborhoods.

Finally, other studies attempt to more explicitly account for exposure and/or health risk. For example, Rosenbaum et al. (2011) combine information on ambient concentrations of diesel particulate matter in marine harbor areas throughout the United States with exposure and carcinogenic risk factors broken out by race, ethnicity and income. They find that the most important factor in predicting higher exposure is population density and that low-income and minority individuals are over-represented in marine harbor areas that exceed risk thresholds. Likewise, Morello-Frosch and Jesdale (2006) combine estimates of outdoor air toxic concentrations with lifetime cancer risks by socioeconomic status and race. They find that even though lifetime cancer risks are high for all individuals (exceeding the 1990 Clean Air Act Amendment goal by several orders of magnitude), lifetime cancer risk is correlated with the degree of racial residential segregation, with the highest risks accruing to non-Hispanic Black, Asian and Pacific Islander, and Hispanic populations in highly segregated neighborhoods. Poverty does not appear to explain differences in lifetime cancer risk by race and ethnicity.

Ringquist (2005) conducts a meta-analysis of both facility location and emissions across 49 studies published prior to 2002 and finds evidence that plant location and higher emissions are positively associated with non-white populations. He finds little evidence, however, that this is the case in communities with lower average household incomes or higher poverty rates. The finding for race holds across a wide variety of environmental risks (e.g., hazardous waste sites and air pollution concentrations), levels of aggregation (e.g., zip codes, census tracts and concentric circles around a facility) and controls (e.g., land value, population density and percent employed in manufacturing). However, the finding for race appears sensitive to the comparison group utilized (e.g., all communities versus a subset of communities).

A potential unintended consequence of improving environmental quality in some communities more than others is that rents may increase in the improved neighborhoods, making them potentially unaffordable for poorer households. For example, Grainger (2012) shows that about half of the increases in home prices due to the Clean Air Act Amendments are passed through to renters. Thus, the net health effect of improvements in environmental quality for renters depends on whether they move. Those who do not move experience higher rents but also improved air quality (and potentially other neighborhood attributes). For those who do move the net effect depends on the quality of the neighborhood to which they relocate. If these households receive far less of the health benefit predicted by a static model, and also face transaction costs from moving in addition to higher rent, they could be worse off. The literature refers to this phenomenon as “environmental gentrification” (see also Banzhaf and McCormick 2012).

Evaluating the potential impact of environmental gentrification may therefore benefit from an analysis of household location decisions, as static models do not capture effects stemming from household sorting.[18] For example, Sieg et al. (2004) find that even with no moving costs, local households could be worse off because other households move into the clean neighborhood and bid up the rents. Earlier work by Banzhaf and Walsh (2008) shows that neighborhood income increased following cleanup, but more recent analysis (Banzhaf et al. 2012) shows racial characteristics in the neighborhood may not change. The authors postulate that richer minorities may move back into neighborhoods following cleanup. Bento and Freedman (2014) find that lower-income homeowners experienced relatively larger reductions in particulate matter emissions post 1990 Clean Air Act Amendments with little evidence of re-sorting after air quality improvements occurred. Using data on repeat residential location choices, Depro et al. (2015)

18 The market dynamics associated with the relationship between household location decisions and pollution was first examined in a rigorous context in Been and Gupta (1997), and further explored by Banzhaf and Walsh (2008).

find that Hispanic households are less willing to give up other types of consumption to reduce cancer risk compared to white households, but that this result is likely driven by large income disparities between the two populations (i.e., the opportunity cost of avoiding cancer risk is higher for Hispanics because they are more income constrained).

10.2.2 Analyzing EJ Impacts in the Context of Regulatory Analysis

In the context of regulatory analysis, examining changes in human health and environmental outcomes or costs can be accomplished, when data are available, by comparing effects in the baseline to those under each regulatory option for minority populations, low-income populations or indigenous peoples.[19] When evaluating human health and environmental outcomes, the following questions can guide consideration of potential analytical methods for assessing EJ.

- As a basis of comparison, what is the baseline distribution of health and environmental outcomes across population groups of concern for pollutants affected by the rulemaking?[20]
- What is the distribution of health and environmental outcomes for the options under consideration for the rulemaking effort?
- Under the options being considered, how do the health and environmental outcomes change for population groups of concern?[21]

Note that these questions ask the analyst to provide information on changes to the distribution of outcomes, but do not ask the analyst to determine whether differences across population groups constitute disproportionate impacts.[22] The term disproportionate is not defined in EO 12898, nor does the academic literature provide clear guidance on what constitutes a disproportionate impact. The determination of whether an impact is disproportionate is ultimately a policy judgment, though one that may be informed by analysis.

This chapter presents a suite of methods for analyzing effects across a variety of regulatory contexts. Because the data, time and resource constraints will differ across programs and rules, these guidelines are intended to provide flexibility to the analyst while introducing greater rigor and transparency in how EJ is considered in a regulatory context.

10.2.2.1 Evaluating Changes in the Distribution of Health and Environmental Outcomes

The analysis of EJ should ideally consider how a regulation affects the distribution of relevant health and environmental outcomes (e.g., mortality risk from a regulated pollutant) across population groups of concern. If outcome data are unavailable, a second-best option is to consider how a regulation affects the distribution of ambient environmental quality indicators (e.g., pollutant concentrations). Such indicators are less informative than the outcomes themselves if, for example, population groups of concern vary in

19 OMB (2003) defines the baseline as “the best assessment of the way the world would look absent the proposed action.” Section 10.2.6 describes the concept of baseline briefly. For a detailed discussion on properly defining a baseline to measure the incremental effects of regulation, see Chapter 5.

20 The term “outcome” indicates that these questions should be interpreted more broadly than just applying to health effects. EPA Program Offices have the flexibility to adapt the wording of these questions to reflect the realities of the specific endpoints under consideration for a rulemaking.

21 It would be useful to quantify the degree to which disparities change from baseline, so that one could rank in order of preference the relative merits of various regulatory options. Any ranking metric, however, would require adoption of an implicit social welfare function. Such approaches are analytically meaningful, but still under development and recommendation of a specific social welfare function is beyond the scope of this chapter.

22 The NEPA Guidance for EJ (CEQ 1997) notes that a population group may be disproportionately affected if health effects are significant or “above generally accepted norms,” the risk or rate of exposure is significant or “appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group,” or is subject to “cumulative or multiple adverse exposures from environmental hazards.”

vulnerability to the pollutant.[23] If projecting changes in ambient environmental quality is not feasible, then a third-best option is for analysts to examine to what extent regulated entities are within a certain proximity of populations of concern (which could be further refined based on characteristics that may correlate with emissions such as plant age or size). Evaluating proximity to emission sources is less desirable than evaluating effects on the distribution of ambient environmental quality or human health outcomes due to uncertainty and local variability in how emission changes affect the health of populations of concern.

As with other types of regulatory analyses, it is important to characterize baseline conditions prior to evaluating how they are affected by each regulatory option.[24] The baseline allows one to determine how the pollutant and its human health and environmental effects are distributed across population groups prior to any regulatory action. It is also the basis of comparison for understanding how a regulation affects the distribution of these health and environmental effects. Baseline assumptions used in an EJ analysis should be consistent with those used in the benefit-cost and economic impact analyses.

Because an unequal distribution of environmental improvements across population groups may actually help alleviate existing disparities, analysts should consider how a regulatory option changes the overall distribution of human health and environmental outcomes, not just how changes in human health and environmental outcomes are distributed across these population groups (Maguire and Sheriff 2011). For example, suppose a policy is expected to reduce a pollutant, causing a greater reduction in adverse health outcomes for non-minority individuals than for minority individuals. One might conclude that this change in the distribution of outcomes could pose an EJ concern. If, however, the non-minority population suffered greater ill effects from the pollutant in the baseline relative to the minority population, then such a change in the distribution of outcomes may reduce, rather than increase, a pre-existing disparity in outcomes.

BCA estimates society's willingness to pay for a change in environmental quality.[25] As an alternative to the change in willingness to pay, one could examine the distribution of physical indicators. Such an evaluation is relatively straightforward if there is only one outcome to consider. Analysis that evaluates multiple outcomes (e.g., asthma risk and fatal heart attack risk) raises the challenge of whether and how to aggregate these outcomes into a single measure, especially when their distributions are dissimilar across populations of concern. Combining several outcomes into a single aggregate measure may be desirable, but it entails normative value judgments regarding the weight to be given to each component. Absent clear guidance on how to make these judgements, analysts should present impacts for multiple outcomes separately.

10.2.2.2 Evaluating How Costs and Economic Impacts Are Distributed Across Populations of Concern

Activities to address EJ often focus on reducing disproportionate environmental and health outcomes in communities. However, certain directives (e.g., EO 13175 and OMB Circular A-4) specifically identify the distribution of economic costs as an important consideration. The economics literature also typically considers both costs and benefits when evaluating the distributional consequences of an environmental policy to understand its net effects on welfare. As discussed in Chapter 9, Tietenberg (2002) and Robinson et al. (2016) describe how regulatory costs can affect product prices, labor compensation and returns to capital, all of which may affect population groups of concern in different ways. Fullerton (2009, 2011)

23 A large epidemiological literature explores differences in health effects across demographic groups. See, for example, Schwartz et al. (2011b).

24 OMB (2003) defines the baseline as "the best assessment of the way the world would look absent the proposed action." See Chapter 5 for a more detailed discussion of baseline issues.

25 The empirical techniques used to monetize health and environmental benefits for BCA estimate an individual's marginal willingness to pay for a change in the outcome. Economic theory suggests that even if all individuals have identical preferences, the marginal willingness to pay to avoid a bad outcome should increase with the level of the outcome. However, marginal willingness-to-pay measures typically used in BCA are constant values. Thus, they cannot be used to evaluate the distribution of the change in welfare across groups may be of interest.

discusses how higher costs of production due to environmental policy may result in higher product prices, decreased production that reduces revenues and affects workers and investors, changes in scarcity rents, and transitional effects. The behavioral change that underlies these costs and economic impacts may also affect the level of environmental risk and health effects faced by populations of concern.

For these reasons, the distribution of health or environment effects alone might convey an incomplete — and potentially biased — picture of the overall burden faced by population groups of concern. For instance, if a regulation results in higher energy prices, low-income households may be particularly hard hit because they spend a greater share of their income on energy compared to other households. Likewise, if low-income population groups live in economically depressed areas dependent on facilities that face increased costs to comply with a new environmental regulation, there may be effects on employment that warrant consideration alongside changes in health effects.

This chapter often frames the discussion in terms of how a regulation affects environmental and health outcomes across population groups of concern given the focus of the EOs, but many of the same methods can be applied to the evaluation of costs and other impacts. Whether to consider costs in an evaluation of EJ issues will depend on the relevance of the information for the regulatory decision at hand; the likelihood that costs will be concentrated among particular types of households or, even if costs are not concentrated, whether their effects are expected to be more pronounced among low-income households; as well as the availability of data and methods to conduct the analysis (see Section 9.5.1 for more discussion of measuring impacts of regulations on consumers).[26]

In many cases, analysis of who bears the economic costs from the regulation are not expected to substantially alter the overall assessment of impacts for population groups of concern. For example, this could be the case if regulatory costs result in a relatively small change in the prices of goods consumed by lower-income households or these households have a high elasticity of demand for these goods (i.e., can substitute away from them easily). When costs are expected to differentially burden populations of concern, further exploration of the distribution of economic costs can offer substantial insight.[27] Such cases may include situations when costs to comply with the regulatory action represent a noticeably higher proportion of income for population groups of concern; some population groups are less able to adapt to or substitute away from goods or services with now higher prices; costs to consumers are concentrated among particular types of households (e.g., renters); there are identifiable plant closures or facility relocations that could adversely affect certain communities; or when households may change their behavior in response to the imposition of costs in such a way that populations of concern are less protected than other groups. Also relevant is consideration of whether other government programs available to low-income households may mitigate some of these effects.

While it is important to find ways to incorporate costs into an analysis of potential EJ concerns when costs are relevant and important, detailed analyses may be challenging due to data or modeling constraints. A static analysis may be possible in some circumstances, but it is challenging to anticipate and model the dynamic effects of a regulatory action on migratory patterns and other types of behavioral change. For example, while hedonic approaches (discussed in Chapter 7) may be useful for demonstrating how changes in environmental

26 Note that there may be other impacts of a regulatory action (e.g., employment effects) beyond direct compliance costs, but understanding how all impacts vary across population groups of concern may not be feasible. For example, data on the distribution of changes in employment across low-income and minority populations may be difficult to assess. See Chapter 9.

27 The regulatory analysis for the EPA's Lead Renovation, Remodeling, and Painting Final Rule (U.S. EPA 2008a) provides an example of consideration of costs in the context of a rulemaking.

quality factor into housing prices, predicting the effect of such price changes on household migration by race or income may be infeasible.[28] Likewise, spatial sorting models have been used in the literature to examine responses to regulation, but they typically limit their focus to a particular city or region.[29]

In addition, incomplete data may prevent fully characterizing the costs borne by population groups of concern. Available data may shed light on baseline distributions but be insufficient for purposes of modeling behavioral changes by household type in response to the costs (or benefits) of a regulatory action.[30] Impacts that cannot be quantified can be qualitatively characterized, including a discussion of key methodological and data limitations and assumptions.

We may expect impacts on population groups of concern to differ in the short run relative to the long run even when all or almost all consumers face similar price changes due to a regulatory action. For instance, in the short run, budget-constrained households may face more difficulties accommodating higher prices than in the long run. In contrast, if there is a robust used market for the regulated good, higher prices due to a regulatory action may initially affect higher income households who purchase new goods. However, over a longer period of time, these higher prices may also affect lower-income households due to higher prices for used goods.

When analyzing the distribution of costs, another consideration is the use of partial versus general equilibrium models for analysis. While general equilibrium models could be utilized to examine first and second-order costs and their implications for changes in wages and prices across households over time, such analyses are typically resource- and time-intensive and are usually only utilized when a large number of sectors are expected to experience significant economic impacts. Such models also are generally focused on medium- to long-run impacts.

10.2.3 Populations of Concern for EJ Analysis

EO 12898 identifies a number of relevant population groups of concern: minority populations, low-income populations, indigenous peoples and tribes, and "populations who principally rely on fish and/or wildlife for subsistence."[31] It may be useful to analyze these categories in combination — for example, low-income minority populations — or to include additional population groups, but such analysis is not a substitute for examining populations explicitly mentioned in the EO. In this section, we discuss existing federal definitions for population groups of concern in the context of EJ. We also discuss credible options for defining these populations absent a federal definition.

10.2.3.1 Minority and Indigenous Peoples

OMB (1997) specifies minimum standards for "maintaining, collecting, and presenting data on race and ethnicity for all Federal reporting purposes [...] The standards have been developed to provide a common language for uniformity and comparability in the collection and use of data on race and ethnicity by Federal agencies." In particular, OMB defines the following minimum race and ethnic categories:

- American Indian or Alaska Native

28 See Section 8.2.5.1 of the *Handbook on the Benefits, Costs and Impacts of Land Cleanup and Reuse* (U.S. EPA 2011b) for a more detailed discussion of EJ in the context of the potential effects of environmental policy on land values and household location decisions.

29 See Kuminoff et al. (2013) for a discussion of equilibrium sorting models used to evaluate household housing choices.

30 Data for exploring differential consumption patterns in the baseline may be available from the Consumer Expenditure Survey, which provides information on the purchase of goods and services across different types of households. The baseline distribution of electricity and other energy prices by household type is also available from the Energy Information Administration. In addition, industry-specific data sources on baseline household consumption patterns may be available for certain types of products or services related to the regulatory scenarios under consideration.

31 EO 12898 clarifies in Section 6 that the EO applies to Native Americans and also Indian Tribes, as specified in 6-606, as well as populations who principally rely on fish and/or wildlife for subsistence as specified in 4-401.

- Asian
- Black or African American
- Native Hawaiian or Other Pacific Islander
- White
- Hispanic or Latino

Statistical data collected by the federal government, such as the U.S. Census Bureau, use this classification system.[32] Beginning with the 2000 Census, individuals were given the option of selecting more than one race, resulting in 63 different categories.[33] OMB (2000) provides guidance on how to aggregate these data in a way that retains the original minimum race categories (i.e., the first five categories listed above; note that the sixth category is an ethnicity and is therefore tracked separately) and four double race categories that are most frequently reported by respondents.[34] In addition, the U.S. Census Bureau collects data useful for identifying minority populations not completely captured by either the race or ethnicity categories, such as households that speak a language other than English at home or foreign-born populations.[35]

The NEPA Guidance for EJ (CEQ 1997) provides direction on defining minority and minority population based on these Federal classifications. Minority is defined as "individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic." A minority population is identified if "either (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis." The term meaningfully greater is not defined, though the guidance notes that a minority population exists "if there is more than one minority group present and the minority percentage, as calculated by aggregating all minority persons, meets one of the above-stated thresholds." The NEPA Guidance for EJ also states that analysts "may consider as a community either a group of individuals living in geographic proximity to one another, or a geographically dispersed/transient set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect."

10.2.3.2 Low-Income Populations

CEQ's NEPA Guidance for EJ (CEQ 1997) states that "low-income populations in an affected area should be identified with the annual statistical poverty thresholds from the Bureau of the Census' Current Population Reports, Series P-60 on Income and Poverty. In identifying low-income populations, agencies may consider as a community either a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect." The extent to which this same definition should be applied in a regulatory analysis will be context specific.

OMB has designated the U.S. Census Bureau's annual poverty measure, produced since 1964, as the official metric for program planning and analytic work by all executive branch agencies in Statistical Policy Directive No. 14 (OMB 1978), although it does not preclude the use of other measures. Many federal

32 Analysts should refer to OMB (1997) for the specific definitions.

33 The U.S. Census Bureau releases two data products every five years with details on race and ethnicity: the Selected Population Tables and the American Indian and Alaska Native Tables. See: https://www.census.gov/programs-surveys/acs/data/race-aian.html (accessed on January 11, 2021).

34 See OMB (2000) for specific guidance on how to conduct this aggregation.

35 For example, see information on these data from the American Community Survey at: https://www.census.gov/topics/population/foreign-born/data/tables/acs-tables.html, and https://www.census.gov/topics/population/language-use.html (accessed on January 11, 2021).

programs use variants of this poverty measure for analytic or policy purposes, and we recommend that EPA analysts also use the U.S. Census Bureau's official poverty thresholds in EJ analyses. The U.S. Census Bureau publishes data tables with several options, described below.

The U.S. Census Bureau measures poverty by using a set of money income thresholds that vary by family size and composition to determine which households live in poverty. If a family's total income is less than the threshold, then that family and every individual in it is considered in poverty. The official poverty thresholds do not vary geographically, but they are updated for inflation using the national Consumer Price Index for All Urban Consumers (CPI-U). The official poverty definition uses money income before taxes and does not include capital gains, tax credits or noncash benefits (such as public housing, Medicaid and food stamps).[36] The way poverty is defined has remained essentially unchanged since its inception, apart from relatively minor alterations in 1969 and 1981.[37]

There is considerable debate regarding this poverty measure's ability to capture differences in economic well-being. In particular, the National Research Council (NRC) recommended that the official measure be revised because "it no longer provides an accurate picture of the differences in the extent of economic poverty among population groups or geographic areas of the country, nor an accurate picture of trends over time" (Citro and Michael 1995). OMB convened an interagency group in 2009 to define a supplemental poverty measure based on NRC recommendations. The U.S. Census Bureau released the Supplemental Poverty Measure (SPM) in November 2011 (Short 2011). This measure uses different measurement units to account for "co-resident unrelated children (such as foster children) and any co-habitors and their children," a different poverty threshold and modified resource measures (to account for in-kind benefits and medical expenses, for example). It also adjusts for differences in housing prices by metropolitan statistical area, as well as family size and composition. The SPM can be a useful complement to the official poverty threshold in the EPA's EJ analyses.

The NRC recognized that annual income is not necessarily the most reliable measure of relative poverty as it does not account for differences in accumulated assets across households. Neither the SPM nor the official U.S. poverty thresholds consider differences in wealth across families. However, the SPM examines whether a household is likely to fall below a specific poverty threshold as a function of inflows of income and outflows of expenses. The U.S. Census Bureau asserts that this measure is therefore more likely to capture short-term poverty since many assets are not as easily convertible to cash in the short run (Short 2012).

The U.S. Census Bureau also includes several additional measures that may prove useful in characterizing low-income families. Unlike poverty, there is no official or standard definition of what constitutes "low-income," though it is expected to vary similarly by region due to differences in cost-of-living as well as with family composition. It is therefore appropriate to examine several different low-income categories, including families that make some fixed amount above the poverty threshold (e.g., two times the poverty threshold) but still below the median household income for the United States or for a region. Including such a low-income category to complement the official poverty definition may help inform an EJ analysis.

36 See "How the Census Bureau Measures Poverty" available at https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html (accessed on April 1, 2020). A list of Census surveys and programs that provide income and poverty estimates is available at https://www.census.gov/topics/income-poverty/poverty/guidance.html (accessed on January 11, 2021).

37 The U.S. Census Bureau produces single-year estimates of median household income and poverty by state and county, and poverty by school district as part of its Small Area Income and Poverty Estimates. It also provides estimates of health insurance coverage by state and county as part of its Small Area Health Insurance Estimates. These data are broken down by race at the state level and by income categories at the county level.

Educational attainment or health insurance coverage may also be useful for further characterizing low-income families relative to other populations, although we caution analysts that some measures may be hard to interpret and use in a regulatory context. It is also possible to examine the percent of people who are chronically poor versus those who experience poverty on a more episodic basis using the U.S. Census Bureau's Survey of Income and Program Participation — which provides information on labor force participation, income and health insurance for a representative panel of households on a monthly basis over several years (see Iceland 2003). Finally, cross-tabulations often are available between many of these poverty measures and other socioeconomic characteristics of interest such as race, ethnicity, age, sex, education and work experience. If appropriate and informative in the regulatory context, these measures may be used as complements to official poverty measures in the EPA's EJ analyses.

10.2.3.3 Populations that Principally Subsist on Fish and Wildlife

EO 12898 directs agencies to analyze populations that principally subsist on fish and wildlife. The NEPA Guidance for EJ (CEQ 1997) defines subsistence on fish and wildlife as "dependence by a minority population, low-income population, Indian tribe or subgroup of such populations on indigenous fish, vegetation and/or wildlife, as the principal portion of their diet." It also states that differential patterns of subsistence consumption are defined as "differences in rates and/or patterns of subsistence consumption by minority populations, low-income populations, and Indian tribes as compared to rates and patterns of consumption of the general population."

Neither the U.S. Census Bureau nor other federal statistical agencies collect nationally representative information on household consumption of fish and/or wildlife. However, the EPA has conducted consumption surveys in specific geographic areas. If fish and wildlife consumption is a substantial concern for a specific rulemaking, the EPA's guidance can provide useful information for collecting these data (see U.S. EPA 1998b). There may also be surveys conducted by state or local governments. It is important to verify that any survey used in an EJ analysis adheres to the parameters and methodology set out in U.S. EPA (1998b).

10.2.4 Data Sources

Many data sources can be used for conducting analyses of EJ issues. In general, the type of analysis that can be conducted depends upon the type and quality of data available. In some cases, spatially-disaggregated individual-level data may be most appropriate and relevant for conducting an analysis of potential EJ concerns. In other cases, distance as a proxy for risk may be the best available relevant metric for conducting the analysis. At times qualitative information will be the best available information for the analysis. In all cases, analysts should use the highest quality and most relevant data and information.

Recognizing the importance of data quality, information needed to conduct an EJ analysis may include:

- Demographic characteristics (e.g., race, ethnicity, age, education, gender);
- Income data (e.g., median household income or percent below poverty level);
- Health data (e.g., hospital and emergency admissions, race/ethnicity-stratified mortality rates, race/ethnicity-stratified asthma or other morbidity rates);[38]
- Other triggers or co-stressors that may be confounders (e.g., low birth weight or asthma; exposure to indoor air pollution);[39]

38 See Chapter 5 of the *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* (U.S. EPA 2016c) for a more detailed discussion of health data.

39 See the *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* (U.S. EPA, 2016c) for a discussion of possible co-triggers and stressors.

- Risk coefficients stratified by socioeconomic variables (e.g., race/ethnicity, income);
- Location of pollution sources (e.g., latitude/longitude coordinates, zip code, county locator);
- Proximity to the nearest source(s) (e.g., distance in miles);
- Distribution of baseline emissions, exposure and risk,
- Modeled changes in the distribution of emissions, exposure and risk under different regulatory options and
- Distribution of economic costs, when relevant (see Section 10.2.2.2).

Socioeconomic data are easily available in more aggregate form from the U.S. Census Bureau's "Quick Facts" website, which contains frequently requested Census data for all states, counties and urban areas with more than 25,000 people.[40] They include population, percent of population by race and ethnicity and income (median household income, per-capita income and percent below poverty line).

In 2010, the U.S. Census Bureau began to administer the decennial Census using a short form to collect basic socioeconomic information. More detailed socioeconomic information is now collected annually by the American Community Survey (ACS), which is sent to a smaller percentage of households than the decennial Census.[41] The ACS provides annual estimates of socioeconomic information for geographic areas with more than 65,000 people, three-year estimates for areas with 20,000 or more people and five-year estimates for all areas.[42] The five-year estimates, which are based on the largest sample, are the most reliable and are available at the census tract and block group levels. Some of the Quick Facts data include estimates from the ACS.

The U.S. Census Bureau's American Housing Survey (AHS), is a housing unit survey that provides data on a wide range of housing and demographic characteristics, including information on renters.[43] Unlike the ACS, which selects a random sample every year, the AHS returns to the same 50,000 to 60,000 housing units every two years.

10.2.5 Scope and Geographic Considerations

While most EPA rules are national in scope, there may be reasons to consider effects at a sub-national level. For instance, there may be differences in implementation at the state level (e.g., as with many waste rules under the Resource Conservation and Recovery Act (RCRA)). A rule may also affect a limited part of the country (e.g., a single-sector regulation where affected facilities are geographically concentrated). In such cases the analyst may wish to evaluate the effects of the regulation at a regional level. For some regulations, such as those governing the use of a household chemical or a product ingredient, geography may not be as relevant for determining how health and environmental outcomes vary across population groups of concern. Two main issues to consider when comparing impacts of a rulemaking on minority populations, low-income populations, and indigenous peoples across geographic areas are:

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40 Quick Facts is available at: https://www.census.gov/quickfacts/fact/table/US/PST045218 (accessed April 1, 2020). Note the year associated with a specific Quick Facts data element, as data are updated as new information becomes available. Not all data elements represent the same year.

41 The ACS is available at: https://www.census.gov/programs-surveys/acs (accessed on January 11, 2021).

42 Because ACS variables change over time, caution should be used when comparing ACS estimates across samples and years. Guidance for comparing ACS data can be found at: https://www.census.gov/programs-surveys/acs/guidance/comparing-acs-data.html (accessed on January 11, 2021).

43 Information on owner-occupied homes versus renters may be useful when exploring issues of gentrification, where renters could be worse off due to rising housing costs.

- Unit of analysis (e.g., facilities or aggregate emissions to which a population group is exposed within a designated geographic area); and
- Geographic area of analysis used to characterize impacts (e.g., county or census tract).[44]

The **unit of analysis** refers to how the environmental harm is characterized. For instance, in a proximity-based analysis the unit of analysis could be an individual facility or the total number of facilities within a specific geographic area (e.g., a county or census tract). In an exposure-based analysis the unit of analysis could be the emissions or ambient concentrations to which the population is exposed aggregated within a specific geographic area. The unit of analysis is often identical to the geographic scale used to aggregate and compare effects on minority populations, low-income populations, and indigenous peoples across areas (see Section 10.2.7 regarding how to select an appropriate comparison group).[45] The choice will vary depending on the nature of the pollutant (e.g., how far it disperses; whether it is possible to identify the specific source of emissions). Another important consideration is whether the data are sufficiently disaggregated to pick up potential variation in impacts across socioeconomic characteristics. More aggregated units of analysis (e.g., metropolitan statistical area (MSA) or county) may mask variation in impacts across socioeconomic groups compared to more disaggregated levels (e.g., facility or census tract) for some types of pollutants.

The **geographic area of analysis** is the area used to characterize impacts (e.g., distance around a facility). Outcomes are aggregated by population group within geographic areas to compare across groups. As with the unit of analysis, the appropriate geographic area will vary depending on the pollutant and regulatory context. Some air pollutants, for example nitrogen oxides (NOx), may travel hundreds of miles away from the source, making it appropriate to choose a large area for measuring impacts. In contrast, water pollutants or waste facilities may affect smaller areas, making it appropriate to consider a smaller area for analysis. Likewise, an assessment of outcomes from specific industrial point sources may require more spatially resolved air quality, demographic and health data than one that affects regional air quality, where coarser air quality, demographic and health data may suffice. Using more than one geographic area of analysis to compare effects across population groups may also be useful since outcomes are unlikely to be neatly contained within geographic boundaries. The literature has demonstrated that results are sensitive to the choice of the geographic area of analysis (Mohai and Bryant 1992; Baden et al. 2007).

Commonly used geographic areas of analysis include:

Counties: The United States has more than 3,000 counties according to the 2012 Census of Governments. Although counties are well-defined units of local government and provide complete coverage of the United States, they vary in size from a few to thousands of square miles, and population density ranges from less than one person per square mile (in some Alaskan counties) to over 66,000 (in New York County). In addition, spatial considerations associated with using counties present concerns for an EJ analysis. For instance, a facility located in one corner of a county may have greater effects on neighboring counties than on residents of the county where the plant is located.[46,47]

Metropolitan and Micropolitan Statistical Areas: The U.S. Census Bureau publishes data on metropolitan and micropolitan statistical areas, as defined by OMB (2009). Metropolitan statistical areas include an urban core and adjacent counties that are highly integrated with the urban core. A micropolitan

44 This is often referred to in the literature as geographic scale.

45 In Fowlie et al. (2012), for example, the scale of the analysis varies between 0.5, 1 and 2 miles of the facility (which is the unit of analysis).

46 These same advantages and disadvantages can apply to other units of government.

47 For criteria pollutants, baseline health data may be available at the county level (e.g., baseline death rates, hospital admissions and emergency department visits).

statistical area corresponds to the concept of a metropolitan statistical area but on a smaller scale. Metropolitan statistical areas have an urban core of at least 50,000 persons and micropolitan statistical areas have an urban core population between 10,000 and 50,000 persons. According to the U.S. Census Bureau, almost 94% of the U.S. population lived in a metro- or micropolitan statistical area in 2010. U.S. rural areas are not covered by these statistical designations.

Zip codes: Zip codes are defined by the U.S. Postal Service for purposes of mail delivery and may change over time. They also may cross state, county and other more disaggregated Census statistical area definitions, making them difficult to use for analysis. Zip code tabulation areas are statistical designations first developed by the U.S. Census Bureau in 2000 to approximately characterize the zip code using available census block level data on population and housing characteristics. Data are readily available for the approximately 33,000 U.S. zip code tabulation areas. While smaller than counties, they also vary greatly in size and population. As a result, they may often be less preferable than other geographic areas for analyzing how effects vary across population groups of concern.

Census tracts/block groups/blocks: Census tracts are small statistical subdivisions of a county, typically containing between 1,500-8,000 persons. The area within a census tract may vary widely, depending on population density. Census tracts in denser areas cover smaller geographic areas. Census tract boundaries were intended to remain relatively fixed. However, they are divided or aggregated to reflect changes in population growth within an area over time. Although they were initially designed to be homogeneous with respect to population characteristics, economic status and living conditions, they may have become less so over time as demographics have changed.

Analysts may also choose to use census blocks or block groups. A census block is a subdivision of a census tract and the smallest geographic unit for which the U.S. Census Bureau tabulates data, containing from 0-600 persons. Many blocks correspond to individual city blocks bounded by streets but may include many square miles, especially in rural areas. And census blocks may have boundaries that are not streets, such as railroads, mountains or water bodies. The U.S. Census Bureau established blocks covering the entire nation for the first time in 1990. Census block groups are a combination of blocks that are within — and a subdivision of — a given census tract. Block groups typically contain 600-3,000 persons.[48]

GIS-based approaches to defining geographic areas: Because Census-based definitions often reflect topographical features such as rivers, highways and railroads, they may exclude affected populations that, although separated by some physical feature, receive a large portion of the adverse impacts being evaluated. Since Census-based definitions vary in geographic size due to differences in population density, Geographic Information System (GIS) software and methods may enable the use of spatial buffers around an emissions source that are more uniform in size and easier to customize to reflect the appropriate scale and characteristics of emissions being analyzed for a given rulemaking. Dasymetric mapping techniques that use land cover information to more accurately distribute populations within selected Census-based boundaries while accounting for physical features may also be useful (e.g., Mennis and Hultgren 2006). Analysts should be aware that there are sometimes challenges when working with geospatial data. Statistical techniques may rely on assumptions that often are violated by these types of data (Chakraborty and Maantay 2011). Analysts should follow best practices in the literature when using these types of data in order to address or minimize these challenges when possible.[49]

48 Other Census statistical area definitions, such as public use microdata areas (PUMAs), are also available.

49 For instance, spatial autocorrelation — when locations in closer proximity are more highly correlated than those further away — violates the assumption that error terms are independently distributed (an assumption that underlies ordinary least squares). There are a variety of ways to test for spatial autocorrelation in the data, such as Moran's I or a Mantel statistical test, as well as methods for addressing it in regression analysis.

10.2.6 Comparison Groups

Since the goal of an EJ analysis is to estimate the differential impacts of a regulation or policy on specific population groups of concern, it is important to understand how these effects compare to those experienced by another group, typically referred to as a comparison group. The choice of a relevant comparison group is important for evaluating relative changes in health, risk or exposure effects across population groups. Within-group comparisons involve comparing effects on the same demographic group across areas in the state, region or nation that are differentially affected by the regulation, while across-group comparisons examine effects for different socioeconomic groups within affected areas. From the perspective of EO 12898, across-group comparisons may be most relevant.

A comparison group should be selected in a way that supports the goal of identifying the role of race and income apart from other systematic differences across groups of people or geographic areas (Rinquist 2005). In an analysis that relies on econometric techniques, this is typically accomplished through the inclusion of control variables. For GIS-based proximity analysis, the comparison group may be defined at a sub-national level in some contexts to reflect differences in socioeconomic composition across geographic regions (Bowen 2001). For instance, because of their larger populations, effects in urban areas may dominate the results of an EJ analysis. If a regulatory action primarily affects rural areas, inclusion of urban areas in the comparison group may mask potentially differential effects that occur for populations of concern living in rural areas.[50] Thus, it is important to articulate clearly how the comparison group is defined in the EJ analysis.

It is also important to keep in mind that a comparison group that is defined too narrowly could substantially reduce variation in the socioeconomic variables of interest. Analysts should be mindful of the potential for biasing results based on the choice of comparison group (Phillips and Sexton 1999; Rinquist 2005) and consider using more than one comparison group to discern the sensitivity of the results to this aspect of the analysis.

10.2.7 Measuring and Estimating Impacts

This section presents potentially useful approaches for describing EJ impacts in regulatory analysis. Basic summary statistics of a regulation's impacts on relevant human health or environmental endpoints by race and income are recommended. When data permit, such statistics are straightforward to calculate, and they promote consistency across the EPA's analytical efforts.

It is important for analysts to conduct a screening analysis for determining when more in-depth analysis of the impacts of a regulatory action on population groups of concern is warranted. While there is no single prescribed screening method, the analyst should review the quality and availability of data, availability of defensible methods to analyze the data, and the peer-reviewed literature and stakeholder input that might be used to evaluate potential EJ concerns.[51] Such information may include the following:

50 Bowen (2001) also argues that restricting the comparison group to alternative locations within the same metropolitan area may be more defensible than a national level comparison in some instances, given heterogeneity across geographic regions in industrial development and economic growth over time and inherent differences in socioeconomic composition (e.g., relatively more Hispanics reside in the Southwest).

51 A screening analysis is also recommended by the EJTG (U.S. EPA 2016c). EJSCREEN may be a useful starting point for a screening analysis in some cases, though it is not sufficient alone. In addition, analysts should be aware of the extent to which the information included in EJSCREEN overlaps with the affected sources and time frame for the regulation. EJSCREEN is not appropriate as a way of identifying an area as an EJ community or as a basis for agency decision-making regarding the existence or absence of EJ concerns (U.S. EPA 2019c). See https://www.epa.gov/ejscreen for more information (accessed on January 11, 2021).

- Proximity of regulated sources to minority populations, low-income populations and/or Indigenous peoples;
- Number of sources that may impact these populations in the baseline;
- Nature and amounts of different pollutants that may already be impacting these populations;
- Any unique exposure pathways associated with the pollutant(s) being regulated;
- Stakeholder concern(s) about the potential regulatory action; and
- History of EJ concerns associated with the pollutant(s) being regulated.

This review may enable the analyst to initially assess potential EJ concerns associated with the regulatory action, and to identify whether more detailed information is available for a more in-depth analysis. It is recommended that the results of the screening analysis be demonstrated through summary statistics.

Summary statistics can be supplemented with other approaches when a screening analysis indicates that a more careful evaluation is needed. The health effects of exposure to pollution may vary across populations (likewise, with economic costs). One way to capture these effects is to use available information on variation in risk and incidence by groups to characterize the baseline and projected response to a change in exposure (for example, see Fann et al. 2011).

Available scientific literature and data (which also often requires some level of spatial resolution) may not allow for a full characterization of potential EJ concerns. In these cases, it is recommended that the analyst qualitatively discuss limitations and sources of uncertainty in the risk and exposure characterization used to assess health effects for minority populations or low-income populations, as highlighted in the literature (U.S. EPA 2016c). When data are available to approximate risk or exposure, for instance locations of emitting facilities, some level of quantitative analysis may be possible.

Similar to the observation in Section 10.2.2 that it is a policy judgement as to whether an impact is disproportionate, there is no commonly accepted way to rank environmental or economic outcomes without making normative judgments regarding how to weigh effects for one population group relative to another. While methods for combining efficiency and equity considerations into one measure exist (e.g., social welfare functions, inequality indices), they are not sufficiently developed for application to EPA regulatory analysis. Nor is there a consensus as to which one should be used. For discussion of the advantages and disadvantages of methods commonly used to rank environmental outcomes, see Text Box 9.1 and Maguire and Sheriff (2011).

10.2.7.1 Summary Statistics

Summary measures can characterize potential differences in baseline and regulatory options within and across populations of concern relative to the appropriate comparison group. However, summary statistics alone do not necessarily provide a complete description of differences across groups as they are not usually calculated for all variables of interest. In addition, summary statistics can mask important details about the tails of the distribution for outcomes of particular relevance for population groups of concern (see Gochfeld and Burger 2011). Nonetheless, such information can prove a useful starting point for understanding potential differences between population groups. After reviewing the available data and feasible methods for developing information on potential differences, the analyst should present information in a transparent and accessible manner such that the decision maker can consider:

- Population groups of concern for the regulatory action;

- Geographic scale and unit of analysis, when relevant;
- Primary conclusions regarding baseline conditions and, when possible, the extent to which different population groups may be affected by the rule (e.g., statistical differences);
- Sources of uncertainty across alternative results (e.g., comparison groups and geographic scale); and
- Data quality and limitations of the results.

A variety of measures can be used to characterize a regulation's effects for population groups of concern. We discuss a few examples below.

Means, medians and quantiles

Reporting geometric mean or median outcomes by group in the baseline and for each regulatory option can be a straightforward way to display information. Tests for statistically significant differences across means or medians are often useful (see Been and Gupta 1997; Wolverton 2009). It is important to be alert, however, to potential changes in the tails of the distribution. For example, the baseline outcomes could be uniformly distributed across the population but become concentrated around the mean or median for the regulatory scenario. Presenting data using different quantiles can provide additional information illuminating these effects.

Ratios

A simple ratio can be calculated to determine whether certain groups are relatively more exposed to an environmental hazard. For instance, an analyst can use a ratio to make an across-group comparison. One can compare the number of individuals within a specific demographic group (e.g., minority or low-income) to the number of individuals outside of the demographic group living within a specified distance of a polluting facility (e.g., three miles). A value of one in this case indicates that there is no distinguishable difference between the number of potentially exposed individuals within the demographic group relative to individuals outside of the demographic group. An analyst also can use a ratio to conduct a within-demographic group comparison. One can compare the number of individuals within a specific demographic group that live close to a regulated facility to the number of individuals from the same demographic group living further away. In this case, a value of one indicates that there is no identifiable spatial pattern where individuals from that demographic group tend to live closer to (or further away from) a regulated facility.

Because ratios may magnify absolute differences, they should be used in conjunction with other statistics. For example, a ratio may show a 100-fold difference between two groups' potential pollution exposure, but the absolute difference may be small.

Tests for Differences

Statistical tests can determine whether a significant disparity exists across demographic groups. One of the simplest is a t-test of the difference in means (i.e., the null hypothesis is that the means between two groups are equal). However, a t-test assumes an underlying normal distribution. For non-normal distributions, nonparametric methods may be used. In cases where comparisons are based on the difference in probabilities between two groups, tests such as the Kendall test and the Fisher Exact test (for small samples) or the Mann-Whitney-Wilcoxon test (for larger samples) may be useful. These tests compare standard errors of two separate and independent statistics to determine how likely it is that the calculated distribution is the actual one. More sophisticated tests (e.g., the Kruskal Wallis test) are needed when making comparisons across more than two groups or a more formal examination of the full distribution is desired.

Correlation coefficients

Simple pair-wise correlations between impacts and relevant demographic groups may be useful for characterizing effects across population groups of concern (e.g., Brajer and Hall 2005). The value of a Pearson correlation coefficient, for example, is a measure of how closely the relationship between two variables (e.g., percent minority population and ambient pollution concentrations) can be represented by a straight line. It does not provide information regarding the slope of the line, apart from being positive or negative. Similarly, a Spearman rank correlation coefficient measures how closely the relationship can be captured by a generic, monotonically increasing or decreasing function. Determination of what constitutes a "strong" or "weak" correlation is somewhat arbitrary, and caution should be used when comparing coefficients across socioeconomic variables of interest.

Counts

A count of geographic areas (e.g., counties) where the incidence of an environmental outcome affected by a rule, disaggregated by race/ethnicity and income, exceeds the overall average is a useful measure. For comparison, this count should be accompanied by a count of geographic areas where the incidence does not exceed the overall average. These counts do not account for the magnitude of differences but can help identify the need for more detailed analysis.

10.2.7.2 Visual Displays

Using GIS software and built-in graphical functions in spreadsheet or statistical software, analysts can produce visual displays of EJ-related information (e.g., maps, charts, graphs). Such displays can illustrate baseline levels of pollutants or locations of certain facilities, and the distribution, demographic profile and baseline health status of population groups of concern.

There are several challenges with using GIS-based visual displays as the main approach to evaluate potential EJ concerns. These include possible spatial and data deficiencies as well as geographic considerations that can lead to misleading or inaccurate results in some cases.[52] It may be difficult to discern differences that arise between baseline and regulatory options, unless such differences are stark. While the use of visual displays in an EJ analysis may help communicate the geographic distribution of impacts, this information may be more effective if it is accompanied by other analytical information (for example, Section 10.2.5 discusses using GIS to create buffers for analysis).

10.2.7.3 Proximity-Based Analysis

Proximity or distance-based analysis is used when direct measures of changes in risk or exposure are not available. This approach examines demographic and socioeconomic characteristics in proximity to a specific location, typically a waste site, permitted facility or some other polluting source subject to the regulation (e.g., Baden and Coursey 2002; Cameron et al. 2012; Wolverton 2009). While a simplistic approach examines the population within a Census-defined geographic boundary, it is also possible to use GIS-based methods to draw a concentric buffer around an emission source, such as a one-mile radius around a site to approximate exposure, or to allow the data to define the appropriate distance through statistical techniques, as is the case for evaluating property value effects.[53,54]

52 See Chakraborty and Maantay (2011) for further discussion of the limitations of using GIS for EJ analyses.

53 See Linden and Rockoff (2008) and Muehlenbachs et al. (2015) for examples of approaches for identifying an appropriate distance.

54 In some cases, it may be possible to use dispersion models to select a buffer that approximates the effect of atmospheric conditions (e.g., wind direction and weather patterns) on exposure, though these types of models are data-intensive (Chakraborty and Maantay 2011).

Several analytical considerations are important for conducting a proximity-based analysis.[55] First, accurate information is needed on the location of regulated sources. Addresses or latitude/longitude coordinates must reflect physical locations of these facilities and not the location of a headquarters building, for example. Second, a decision regarding the appropriate distance from the facility is needed. A solid waste facility with strict monitoring and safety controls is likely to have a limited geographic impact, whereas a permitted air pollution source may have the potential for a more widespread geographic impact. In general, Census-defined geographic boundaries (e.g., county, MSA) are unlikely to provide an accurate portrayal of the potential effects on the relevant affected population when emission sources are located along a boundary and thus mostly affect a neighboring jurisdiction, when the affected population is not uniformly distributed within the geographic boundary, or when pollutant exposures do not conform to the boundary.[56]

In addition, Census-defined areas often vary widely in size, implying that they may differ in how well they proxy for actual exposure. Using buffer-based approaches (e.g., through GIS or fate and transport modeling) around an emissions source has the potential to more closely approximate actual risk and exposure, but the appropriate distance measure can vary by situation. The literature has demonstrated that results in proximity-based analyses can vary substantially with the choice of the geographic area of analysis (see Sheppard et al. 1999; Rinquist 2005; Baden et al. 2007; Mohai and Saha 2007; Mohai and Saha 2015a; Mohai and Saha 2015b). For this reason, it is recommended that the analyst explore the potential value of defining and applying more than one specification for distance or proximity.[57]

When a proximity-based approach is used, analysts should explain why it is not feasible to pursue an exposure-based modeling approach. It also is important to discuss the biases and limitations introduced when proximity or distance is used as a substitute for risk and exposure (see Chakraborty and Maantay 2011). For instance, regardless of how the boundary is defined, proximity-based approaches typically account for the effects of a stressor only within a designated boundary.

10.2.7.4 Exposure Assessment

Spatial patterns of health or environmental effects — and changes in those effects — are difficult to analyze when pollution is diffuse. Air and water pollution, for example, are typically dispersed widely and may undergo physical, chemical and other changes once released to the receiving media, thus changing the nature of the risk posed. While identifying the "proximity" to the hazards via GIS analysis is difficult in these cases, monitoring and/or modeling data may still allow for an assessment of effects at a disaggregated level. Criteria air pollutants (i.e., carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter and sulfur dioxide) are monitored nationally. The EPA's National Air Toxics Assessment (NATA) data provide an assessment of hazardous air pollutants across the U.S. at the census tract level. Data from these sources may be combined with demographic data and dispersion models to generate baseline and regulatory distributions of pollutants by population groups of concern.[58]

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55 For an overview of proximity analysis, including a discussion of various spatial analysis techniques used in the literature, see Chakraborty and Maantay (2011), and Mohai and Saha (2007).

56 Mohai and Saha (2007) refer to this as the "unit-hazard coincidence" approach because the analyst uses the available geographic units and determines whether they are coincident with an environmental hazard instead of first identifying the exact location of the hazard and then examining effects within a particular distance.

57 See EPA's Definition of Solid Waste for an example of this type of EJ analysis in a rule-making context. See EPA (2014c).

58 For examples of studies that have used this approach to evaluate ambient concentrations of particular matter, see Fann et al. (2011), Rosenbaum et al. (2011), and Post et al. (2011).

While this approach is promising due to the spatial detail of the data, it is currently only available for certain air pollutants. In addition, the data measure emissions, not individual exposures or health effects associated with the pollutant under consideration. These data are therefore still a proxy for actual effects associated with a specific regulation. Actual exposures or health effects may differ across individuals for a variety of reasons discussed throughout this chapter.

10.2.7.5 Risk Considerations

Activities linked to a specific culture or socioeconomic status could expose some populations groups of concern to higher levels of pollution both in the baseline and after a regulation is put in place. For example, some indigenous peoples and immigrant populations rely on subsistence fishing, which could result in higher mercury levels from consumption of fish or expose these populations to other forms of pollution if fishing occurs in contaminated waters (see Donatuto and Harper 2008).[59]

In addition to the potential for greater exposure to environmental risk, certain pre-existing factors also make some populations more susceptible (i.e., experience a greater biological response) to a specific environmental stressor for a given level of exposure (see Adler and Rehkopf 2008; Sacks et al. 2011; Schwartz et al. 2011a).[60,61] These factors can be genetic or physiological (such as sex and age). They may also be acquired due to variation in factors such as health care access, nutrition, fitness, stress, housing quality, other pollutant exposures or drug and alcohol use.[62] For instance, many populations face exposures from multiple pollutants that have accumulated in ways that affect susceptibility due to pre-existing disease and adverse health conditions. In such instances, addressing EJ concerns is complicated.[63] See the EJTG (U.S. EPA 2016c) for a more detailed discussion of risk considerations.

10.2.7.6 Identification and Analysis of Potential Community "Hot Spots"

"Hot spot" is a term that is often used to refer to one or more geographic areas with the potential for a higher level of exposure to pollution or contamination than occurs within a larger geographic area of lower or more "normal" exposure. Populations and communities in these geographic areas may face potential EJ impacts if higher exposure results in more concentrated environmental risk or negative health outcomes for population groups of concern. Relevant issues in a local setting may include exposure pathways and drivers of differential susceptibility. It is important to note that hot spots may result from conditions that exist prior to the regulatory action, such as stressors within the community, or may be created as a result of the regulatory action.

It may be possible to identify the areas that have the potential for elevated levels of pollution or contamination using quantitative proximity analyses. In addition, information received via public comments can yield insights into potential hot spots. In cases where sites are relatively small in number, in-depth qualitative analysis may be useful.[64] More sophisticated approaches may be required (e.g., fate and transport modeling) when potential hotspots are more numerous or widespread.

59 It is also worth considering conditions that reduce a community's ability to participate fully in the decision-making process such as time and resource constraints, lack of trust, lack of information, language barriers and difficulty in accessing and understanding complex scientific, technical and legal resources (see Dietz and Stern 2008).

60 A December 2011 special issue of the American Journal of Public Health (Volume 101, Issue S1) includes a set of papers exploring these and other issues.

61 EPA's Integrated Risk Information System (IRIS) defines susceptibility as "increased likelihood of an adverse effect, often discussed in terms of relationship to a factor that can be used to describe a human subpopulation (e.g., life stage, demographic feature or genetic characteristic)." See http://www.epa.gov/iris/help_gloss.htm#s (accessed on January 11, 2021).

62 Sexton (1997) suggests that low-income families may be more susceptible to environmental stressors due to differences in quality of life and lifestyle. Centers for Disease Control data show higher incidences of asthma-related emergency room visits and asthma-related deaths among African American populations. See http://minorityhealth.hhs.gov/templates/content.aspx?ID=6170 (accessed on January 11, 2021).

63 EPA (2003e) may serve as a useful reference when assessing how prior exposures may affect the impacts of emission changes from the rule being analyzed.

64 See Grineski (2009), Rao et al. (2007), Arcury et al. (2014), and Schwartz et al. (2015) for examples.

10.3 Environmental Health for Children and Older Adults

Analysis may shed light on differential effects of regulation on children and older adults, both of which are life-stage defined groups characterized by a multitude of unique behavioral, physiological and anatomical attributes. EO 13045 requires that each federal agency address disproportionate health risks to children. In addition, the EPA's Children's Health Policy (U.S. EPA 1995) requires the Agency to "consider the risks to infants and children consistently and explicitly as a part of risk assessments generated during its decision-making process, including the setting of standards to protect public health and the environment."[65]

There are two sets of important differences between children and adults regarding health effects. First, there are differences in exposure to pollutants and in the nature and magnitude of health effects resulting from the exposure. Children may be more vulnerable to environmental exposures than adults because their bodily systems are still developing; they eat, drink and breathe more in proportion to their body size; their metabolism may be significantly different — especially shortly after birth; and their behavior can expose them more to chemicals and organisms (e.g., crawling leads to greater contact with contaminated surfaces, while hand-to-mouth and object-to-mouth contact is much greater for toddler age children). In addition, since children are younger, they have more time to suffer adverse health effects from exposure to contaminants. Second, individuals may systematically place a different economic value on reducing health risks to children than on reducing such risks to adults. In part this is because children cannot provide marginal willingness to pay values for their own risk reductions, unlike adults, so children's health risk valuation necessarily requires some model, implicit or explicit, about household decision making. These models differ in their implications for valuation. The perceived or actual effects of a given health outcome, too, may differ across children and adults. Empirical evidence also suggests that parents value a given risk reduction to themselves differently than to their children, with willingness to pay (WTP) for own risks generally valued less than those for children.[66]

Older adults also may be more susceptible to adverse effects of environmental contaminants due to differential exposures arising from physiological and behavioral changes with age, disease status and drug interactions, as well as the body's decreased capacity to defend against toxic stressors.

Generally, many of the approaches described earlier in this chapter to characterize the distribution of impacts may be adapted to evaluate environmental health risks by life stage.[67] For example, when proximity-based analysis is appropriate for evaluating EJ impacts, it might also be used to examine whether children or older adults are disproportionately located near facilities of concern. In such a case, the considerations described earlier about geography, defining the baseline and comparison groups, and use of summary statistics would all apply.

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65 See https://www.epa.gov/children/epas-policy-evaluating-risk-children for the original 1995 policy and the 2013 and 2018 reaffirmation memos (accessed on April 1, 2020).

66 See Gerking and Dickie (2013) for a review of both household decision making models for children's health risk valuation and the empirical literature. U.S. EPA (2003b) provides an overview of children's health valuation issues in applied analysis.

67 In principle there is a potential distinction between factors that are fixed, such as race and sex, and those defined by lifestages. The latter raises the possibility, at least, of examining effects through the lens of differences in lifetime utility or well-being rather than focusing on a single life stage. See Adler (2008) for one proposal consistent with this approach.

10.3.1 Age as a Life Stage

Evaluating the impacts of regulatory actions on children or older adults differs in an important way from evaluating the same impacts on population groups of concern for EJ. For instance, when the EPA evaluates disproportionate health risk impacts from environmental contaminants, it views childhood as a sequence of life stages from conception through fetal development, infancy and adolescence, rather than a distinct "subpopulation."

Use of the term "subpopulation" is ingrained in both the EPA's past practices as well as various laws that the EPA administers such as the Safe Drinking Water Act Amendments. Prior to the publication of revised risk assessment guidelines in 2005, the EPA described all groups of individuals as "subpopulations." In the 2005 guidelines, the Agency recognizes the importance of distinguishing between groups that form a relatively fixed portion of the population, such as those described in Section 10.2, and life stages or age groups that are dynamic groups drawing from the entire population.

The term "life stage" refers to a distinguishable time frame in an individual's life characterized by unique and relatively stable behavioral and/or physiological characteristics associated with development and growth. Since 2005, the EPA has characterized childhood as a life stage.[68]

10.3.2 Analytical Considerations

Assessing the consequences of policies that affect the health of children or older adults requires considerations that span risk assessment, action development and economic analysis. In each case, existing Agency documents can assist in the evaluation.

10.3.2.1 Risk and Exposure Assessment

Effects of pollution may differ depending upon age of exposure. Analysis of potentially disproportionate impacts begins with health risk assessment but also includes exposure assessment. Many risk guidance and related documents address how to consider children and older adults in risk and exposure assessment.

A general approach to considering children and childhood life stages in risk assessment is found in *A Framework for Assessing Health Risks of Environmental Exposures to Children* (U.S. EPA 2006a). The framework identifies existing guidance, guidelines and policy papers that relate to children's health risk assessment. It emphasizes the importance of an iterative approach between hazard, dose response and exposure analyses. In addition, it includes a discussion of principles for weight-of-evidence consideration — that is, the critical evaluation of available and relevant data — across life stages.

The EPA's 2005 *Guidelines for Carcinogenic Risk Assessment (Cancer Guidelines)* (U.S. EPA 2005e) explicitly call for consideration of possible sensitive subpopulations and/or lifestages such as childhood. The *Cancer Guidelines* were augmented by *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (U.S. EPA 2005f). Recommendations from this supplement include calculating risks utilizing life stage-specific potency adjustments in addition to life stage-specific exposure values which should be considered for all risk assessments.

68 The 2005 Risk Assessment Guidelines "view childhood as a sequence of lifestages rather than viewing children as a subpopulation, the distinction being that a subpopulation refers to a portion of the population, whereas a life stage is inclusive of the entire population." (U.S. EPA 2005e).

The EPA's *Child-Specific Exposures Handbook* (U.S. EPA 2008b) and *Highlights of the Child-Specific Exposure Factors Handbook* (U.S. EPA 2009c) help risk assessors understand children's exposure to pollution. The handbook provides important information for answering questions about life stage-specific exposure through drinking, breathing and eating. The EPA's guidance to scientists on selecting age groups to consider when assessing childhood exposure and potential dose to environmental contaminants is identified in *Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants* (U.S. EPA 2005g).

While there is no standard framework for including economic and human health effects on older adults in an analysis of the impacts of regulation, the EPA stresses the importance of addressing environmental issues that may adversely impact them.[69] These considerations are highlighted in the EPA's *Exposure Factors Handbook* (U.S. EPA 2011c) and have led the EPA's Office of Research and Development to consider an exposure factors handbook specifically for the aging (see U.S. EPA 2007). Additionally, the toxicokinetic and toxicodynamic impacts of environmental agents in older adults have been considered in the EPA's *Aging and Toxic Response: Issues Relevant to Risk Assessment* (U.S. EPA 2005h).

10.3.2.2 Action Development

Disproportionate impacts during fetal development and childhood are considered in EPA guidance on action development, particularly the *Guide to Considering Children's Health When Developing EPA Actions: Implementing Executive Order 13045 and EPA's Policy on Evaluating Health Risks to Children* (U.S. EPA 2006b). The guide helps determine whether EO 13045 and/or the EPA's Children's Health Policy applies to an EPA action and, if so, how to implement the Executive Order and/or the EPA's Policy. The guide clearly integrates the EPA's Policy on Children's Health with the Action Development Process and provides an updated listing of additional guidance documents.

10.3.2.3 Economic Analysis

While these *Guidelines* provide general information on BCA of policies and programs, many issues concerning valuation of health benefits accruing to children are not covered. Information provided in the *Children's Health Valuation Handbook* (U.S. EPA 2003b), when used in conjunction with the *Guidelines*, allows analysts to characterize benefits and impacts of Agency policies and programs that affect children.

The *Handbook* is a reference tool for analysts conducting economic analyses of EPA policies when those policies are expected to affect risks to children's health. The *Handbook* emphasizes that regulations or policies fully consider the economic impacts on children, including incorporating children's health considerations into BCA, as well as a separate analysis focused on children.

Economic factors may also play a role in other analyses that evaluate children's environmental health impacts. For example, because a higher proportion of children than adults live in poverty, the ability of households with children to undertake averting behaviors might be compromised.[70] This type of information could inform the exposure assessment.

69 There is a lack of broad agreement about when this life stage begins. The U.S. and other countries typically define this life stage to begin at the traditional retirement age of 65, but, for example, the U.N. has it begin at age 60 (U.S. EPA 2005h).

70 U.S. Census Historical Poverty Tables: People and Families - 1959 to 2018. https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-people.html (accessed on January 11, 2021).

Analysis of who bears the costs and benefits of a policy also is complicated by the fact that individual life stages change over time. For instance, because children eventually grow into adults, health and other benefits of a policy that initially accrue mainly to children will also likely affect them as adults. Likewise, while the costs of a policy are initially borne by current adults, they will eventually be borne by the current set of children as they themselves become adults.

10.3.3 Intersection Between Environmental Justice and Children's Health

The burden of health problems and environmental exposures is often borne disproportionately by children from low-income communities and minority communities (e.g., Israel et al. 2005; Lanphear et al. 1996; Mielke et al. 1999; Pastor et al. 2006). The challenge for the EPA is to integrate both EJ and life stage susceptibility considerations, particularly for children but also for older adults, where appropriate when conducting analysis. This is especially true when short-term exposure to environmental contaminants, such as lead or mercury, early in life can lead to life-long health consequences.