Chapter 10 - Environmental Justice and Life Stage Considerations

Instead of focusing on quantifying and monetizing total benefits and costs, an evaluation of the impacts of a regulation 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 people of color, low-income or Indigenous populations (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 2023) regarding distributional analysis, several EOs, described more fully in Chapter 2, directly address different types of effects for population groups of concern: [3]

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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.

2 Some environmental statutes also identify population groups that may merit additional consideration. See EPA Legal Tools to Advance Environmental Justice (U.S. EPA 2022) for a review of legal authorities under the environmental and administrative statutes administered by the EPA.

3 This chapter addresses analytical components of EOs 12898 and 14096 and does not cover other components such as ensuring proper outreach and meaningful involvement.

- EO 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” (1994), calls on each federal agency to make achieving EJ part of its mission to the greatest extent practicable and permitted by law "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 in the United States."
- EO 14096, "Revitalizing Our Nation's Commitment to Environmental Justice for All" (2023), supplements EO 12898 and calls on agencies to, as appropriate and consistent with applicable law, identify, analyze, and address:
  - Disproportionate and adverse human health and environmental effects…, including those related to climate change and cumulative impacts of environmental and other Burdens on communities with environmental justice concerns;
  - Historical inequities, systemic barriers, or actions related to any Federal regulation, policy, or practice that impair the ability of communities with environmental justice concerns to achieve or maintain a healthy and sustainable environment; and
  - Barriers related to Federal activities that impair the ability of communities with environmental justice concerns to receive equitable access to human health or environmental benefits, including benefits related to natural disaster recovery and climate mitigation, adaptation, and resilience.
- 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.
- 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.”
- 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.[4]
- EO 14094, "Modernizing Regulatory Review" (2023), supplements, reaffirms, and amends 12866, and confirms that "[r]egulatory analysis, as practicable and appropriate, shall recognize distributive impacts and equity, to the extent permitted by law."

10.2 Environmental Justice

This section offers a high-level summary of analytic expectations and recommendations for evaluating environmental justice concerns for EPA regulatory actions, consistent with *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* (*EJ Technical Guidance*) (U.S. EPA 2024a). Analysts should consult the *EJ Technical Guidance* for additional detail on analytic approaches and considerations.

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

An analysis of EJ concerns for regulatory actions should address three questions:[5]

- **Baseline:** Are there existing EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern?[6]
- **Regulatory options:** For the regulatory option(s) under consideration, are there potential EJ concerns associated with environmental stressors that are affected by the regulatory action for population groups of concern?
- **Mitigation or exacerbation of effects:** For the regulatory option(s) under consideration, are EJ concerns exacerbated, mitigated, or unchanged compared to the baseline?

These questions provide the framework for analyzing the effects of a regulatory action on 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. These challenges will vary by media and regulatory context, including the availability of information generated from human health risk and exposure assessments, or other components of the regulatory analysis.

The EPA encourages analysts to document key reasons why a particular question cannot be addressed to help identify future priorities for filling key data and research gaps. A lack of existing data and methods does not mean there is no EJ concern, so identifying such gaps is important. Regardless of the approach taken, the highest quality and most relevant data should be applied in a manner consistent with the OMB and EPA data quality guidelines (OMB 2019; U.S. EPA 2012; U.S. EPA 2002) and the *Peer Review Handbook* (U.S. EPA 2015).

The term "disproportionate" is used here to refer to differences in effects or risks that are extensive enough that they may merit Agency action and should include consideration of cumulative impacts or risks where appropriate and consistent with applicable law (U.S. EPA 2022). In general, the determination of whether a difference in effects or risks is disproportionate is ultimately a policy judgment which, while informed by analysis, is the responsibility of the decision-maker.[7] The terms "difference" or "differential" indicate an analytically discernible (or measurable) distinction in effects or risks across population groups. It is the role of analysts to assess and present differences in anticipated effects across population groups in the baseline and for the regulatory options, using the best available information (both quantitative and qualitative) to inform the decision-maker and the public.

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5 An EJ concern is the actual or potential lack of just treatment or meaningful involvement of any population group, community, or geographic area (e.g., associated with differences in income, race, color, national origin, Tribal affiliation, or disability status) in the development, implementation, and enforcement of environmental laws, regulations, and policies. For analytic purposes, this concept refers specifically to disproportionate and adverse health and environmental effects that may exist prior to or be created by the regulatory action.

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

7 A finding of disproportionate and adverse effects is neither necessary nor sufficient for the EPA to address them. The Agency's statutory and regulatory authorities provide a broad basis for protecting human health and the environment and do not require a demonstration of disproportionate effects to protect the health or environment of any population.

10.2.1 Population Groups of Concern

At an early stage of the analysis, analysts need to identify the population groups of concern relevant to a specific regulatory context.[8] The concept of vulnerability can be used to help identify population groups of concern.[9] For example, analysts can combine available data on baseline health, demographic, socioeconomic, or other relevant indicators (including those related to cumulative impacts, historic inequities and systemic barriers, and lack of access) to identify characteristics in affected communities that correlate with increased vulnerability to environmental exposure or lack of opportunity for public participation (Fann et al. 2011).

While the EPA does not have rigid criteria for identifying population groups of concern, E.O.s 12898 and 14096 reference race, ethnicity, national origin, low-income, disability status, Tribal affiliated and Indigenous populations, and those engaged in cultural or subsistence practices. Note that population groups of concern may be clustered within specific communities or geographically dispersed (e.g., unhoused populations, migrant workers). Underserved communities or populations also may warrant consideration.[10] See the *EJ Technical Guidance* (U.S. EPA 2024a) for more in-depth discussion.

It may be useful in some contexts to analyze population groups in combination or to evaluate additional aspects of diversity within a specific population group of concern (e.g., by life stage, gender), particularly when some individuals within a population group may be at greater risk for experiencing disproportionate and adverse effects (e.g., due to unique exposure pathways). Analysts should rely on the Office of Management and Budget (OMB) or other federal statistical agencies (e.g., U.S. Census Bureau), when available, to define relevant population groups (or combinations thereof) for a specific regulatory action. Note that analysis of additional population groups is not a substitute for examining the population groups explicitly mentioned in the E.O.s.

10.2.2 Main Steps of an EJ Analysis

Conducting a preliminary analysis may be a useful first step to identifying what level of assessment is feasible and appropriate to support the regulatory action. In addition, it can help identify the extent to which a regulatory action may raise EJ concerns that need further evaluation. Feasibility is informed by a technical evaluation of available data and methods, including:

- Scientific literature that discusses the effects of the stressor(s) being regulated on population groups of concern;
- Information received via public comments, technical reports, press releases, or other documentation discussing the environmental and health effects of the stressor(s) being regulated for population groups of concern, including information on other relevant environmental or non-environmental stressors;

8 The term population groups of concern is used instead of the term subpopulations to include "population groups that form a relatively fixed portion of the population (e.g., based on ethnicity)." See the EPA's Early Life Stages website: http://www.epa.gov/children/early-life-stages.

9 Note that specific terminology and definitions related to vulnerability may be provided by statute.

10 Examples of other characteristics that may be relevant in some regulatory contexts include linguistic isolation, occupation, rurality, and employment status, among others.

- Availability of spatially disaggregated data for population groups that may live, work, or play in close proximity to the stressor(s) being regulated, or may otherwise be affected by the stressor(s); or
- Availability of methods for conducting in-depth analysis (e.g., proximity-based approach, risk- or exposure-assessment, and mixed methods approach).

If the preliminary analysis reveals that the scientific literature and data are unavailable or of insufficient quality to pursue an in-depth analysis that characterizes how exposure, risk, or health effects are distributed across population groups, analysts are expected to explain why additional analysis is not possible. In particular, analysts are encouraged to discuss relevant evidence, key limitations, and sources of uncertainty highlighted in the published literature. Some impacts that cannot be quantified may still represent important effects that should be considered in the analysis.

When conducting further evaluation is determined to be both feasible and appropriate, an EJ analysis typically includes five main steps (Figure 10.1). We briefly describe each step below.

Figure 10.1 - Main Steps of an EJ Analysis

Identify Regulated Sources
- Where are regulated sources located?
- Do health and environmental risks vary with source characteristics?
- Do the regulatory options vary with source characteristics?

Describe Environmental Stressors
- Is the pollutant spatially distributed?
- What is known about fate and transport?
- What are the relevant health outcomes?

Characterize Affected Populations
- What factors might drive higher exposure?
- What factors might drive differential exposure?
- How do health outcomes vary by population group or community?

Compare Affected and Compariosn Populations
- Given data and methods, are you only characterizing the baseline or also regulatory options?
- How are you presenting and characterizing results?

Conduct Sensitivity Analysis
- What are key uncertainties and limitations?
- Are there specific pockets of concern?
- What are they key assumptions?

Questions to Ask at Each Step
- How can meaningful engagement inform the EJ analysis?
- What data are available and at what spatial scale?
- What tools are available to model exposure and/or risk?
- How are the effects distributed across sources and communities?

(1) Identify the sources being regulated: Before analysts can identify the populations and communities being affected by a regulatory action, it is important to first characterize the regulated sources: where are they located? Are there particular characteristics of the regulated sources that contribute to higher exposure and/or risk of health effects? Do the regulatory options vary with these characteristics? For instance, are some sources subject to greater stringency or other regulatory requirements that would be important to account for in the EJ analysis?

(2) Describe the environmental stressor: The spatial distribution of health and welfare outcomes is a relevant consideration for some regulatory actions. In these cases, evidence on the fate and transport of the environmental stressor can help determine the populations and communities potentially exposed. In other cases, the regulatory action's effects may be more widespread. It is also important to understand which specific health effects are of greatest relevance for a given regulatory context. The benefits analysis and, when conducted, the human health risk and exposure assessments can be important sources for this information.

(3) Characterize affected populations: It is important to understand what factors may contribute to EJ concerns. How are individuals being exposed? Are there unique pathways or other factors that drive higher exposures for some population groups? Recognizing underlying contributors within a specific regulatory context is important for properly assessing EJ concerns and can aid in the design of regulatory options. This may include evidence of already overburdened communities, including the cumulative effects of exposure to multiple environmental or non-environmental stressors on human health and well-being.

(4) Compare the affected and comparison groups: To answer each of the three analytic questions, analysts need to characterize the exposure and risk of health effects for population groups of concern in the baseline and for the regulated action relative to a comparison population group (see Section 10.2.6). This allows analysts to gauge the extent to which effects for the affected population are similar or different than they are for the comparison group and how they vary across population groups.

(5) Conduct sensitivity analysis: Due to the inherent limitations and uncertainties associated with analyses of EJ concerns, conducting sensitivity analysis around key assumptions is particularly important for clearly communicating results to the public.

Figure 10.1 also identifies four overarching questions that are relevant throughout the EJ analytic process:

1. **How can meaningful engagement inform the EJ analysis?**

   Meaningful engagement can help analysts to identify and sometimes help fill information and data needs. It can also help analysts to identify factors such as unique pathways or pre-existing vulnerabilities that may contribute to exposure and/or risk for affected populations. See U.S. EPA (2024a) and U.S. EPA (2024b) for more information.

2. **What data are available and at what spatial scale?**

   The quality and availability of data are key determinants in the scope and complexity of the EJ analysis. In some cases, analysts will have data at the individual level for the environmental stressor being regulated, allowing for a detailed, rigorous analysis. In other cases, analysts may need to rely on proxies for individual-level effects. Data relevant to the EJ analysis may include, but are not limited to, the demographic and socioeconomic characteristics of populations that may be exposed to environmental stressors from regulated sources, what each regulated source is emitting or discharging, and pre-existing health conditions or other environmental and non-environmental stressors that increase the vulnerability and therefore the risk of experiencing a health effect for some population groups.

3. **What tools are available to model exposure and/or risk?**

   Analysts have a choice among several scientifically defensible methods to assess EJ concerns associated with a regulatory action, including proximity-based analysis, exposure and risk modeling, and combining qualitative and quantitative approaches. The choice of a specific analytic method for the EJ analysis is often driven by data availability. Together, the data and methods utilized directly influence what conclusions can be drawn regarding EJ concerns for specific population groups or communities. Chapter 6 of the *EJ Technical*

Guidance (U.S. EPA 2024a) discusses the main methods available and the potential advantages and disadvantages of each in more detail.[11]

4. **How are the effects distributed across sources and communities?**

   In some cases, extensive differences in effects among population groups of concern may occur in only a few geographic locations. Referred to as hot spots, these locations are typically exposed to localized concentrations of emissions from one or more sources along with other stressors. In these cases, it may be appropriate to tailor the analysis to evaluate effects in a few specific areas. Identifying the potential for hot spots early helps analysts develop appropriate sources of data and analytic approaches, which may differ from those used for a broader analysis (see Section 10.2.7.5).

10.2.3 Recommendations for Analyses of EJ Concerns

The *EJ Technical Guidance* (U.S. EPA 2024a) makes five overarching recommendations to ensure a high-quality EJ analysis, while also recognizing the need for flexibility to reflect policy considerations and technical challenges within a particular regulatory context. The recommendations are intended to bring greater consistency across EJ analyses as they strive to answer the three analytic questions but are not prescriptive and do not mandate the use of a specific approach. Analysts should use their best professional judgement to decide on the type of analysis that is feasible and appropriate within a specific regulatory context.

While these recommendations and best practices are intended as a starting point, they should not be interpreted as limiting the scope of the EJ analysis. It is recommended that analysts thoughtfully tailor their analysis to the rule context and incorporate new data and methods as they become available. Ultimately, the EPA strives to innovate and improve upon EJ analyses as the state of science continues to evolve. The five overarching recommendations are:

1. **When risks, exposures, outcomes, or benefits of the regulatory action are quantified, some level of quantitative EJ analysis is recommended.**
   a. Analysts should present information on estimated health and environmental risks, exposures, outcomes, benefits, or other relevant effects disaggregated by race, ethnicity, income, and other relevant demographic and socioeconomic categories when feasible and appropriate.
   b. When such data are not available, it may still be possible to evaluate potential risk or exposure using other metrics (e.g., proximity to affected facilities, cancer or asthma prevalence, or evidence of unique exposure pathways for specific population groups) in a scientifically defensible way.
   c. When health and environmental outcomes or benefits are not quantified or disaggregated by race, ethnicity, income, or other relevant demographic and socioeconomic categories, analysts should present available quantitative and/or qualitative information that sheds light on EJ concerns that may arise.

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

2. **Analysts should integrate EJ into the planning of a risk assessment conducted for the regulatory action.**[12]
3. **Analysts should strive to characterize the distribution of risks, exposures, or outcomes within each population group, not just average effects.**
    a. In particular, analysts should pay attention to whether populations in the upper tail of the distribution face the highest adverse risks, exposures or health effects.
4. **Analysts should follow best practices appropriate to the analytic questions at hand (see Text Box 10.1).**
5. **As relevant, analysts should consider any economic costs or challenges that may be exacerbated by the regulatory action for relevant population groups of concern.**
    a. For instance, it may be appropriate to consider how low-income populations are affected by price changes or to consider the distribution of economic costs (i.e., private and social costs) more broadly from an EJ perspective.

10.2.4 Characterizing the Baseline and Regulatory Options for In-Depth EJ Analysis

The five main steps of an in-depth EJ analysis can be applied to characterize baseline conditions, evaluate the effects of the regulatory options, and make comparisons between the two to evaluate the three analytic questions, when data and methods allow.

The OMB (2023) defines the baseline as "an analytically reasonable forecast of the way the world would look absent the regulatory action being assessed, including any expected changes to current conditions over time." It includes the characteristics of current populations and how they are affected by pollutant(s) prior to the regulatory action under consideration. As the OMB definition implies, however, the baseline is not a static concept. In particular, the OMB notes that analysts may need to consider the evolution of the market, compliance with other regulations, and the future effect of current government programs and policies, as well as other relevant external factors to project future baseline conditions. As discussed in chapter 5, how future regulations or policies affect the baseline specification is complex and requires consideration of many factors. Ideally all potential influences on baseline conditions would be estimated, but it is generally not practicable to do so. Anticipated changes in baseline demographic composition may also be relevant in an EJ context. Per the recommendations in Section 10.2.2, the baseline for the EJ analysis, including the geographic scope, year of analysis, and health and other effects, should be consistent with how it is specified in other parts of the regulatory analysis.

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12 For more information on this recommendation, see Chapter 5 of U.S. EPA (2024a).

Text Box 10.1 - Current Best Practices for Evaluating EJ Concerns

- Use the best available science while relying on current, generally accepted Agency procedures for conducting risk assessment and economic analysis.
- Use existing frameworks and data from other parts of the regulatory analysis, supplemented as appropriate.
- Be consistent with the basic assumptions underlying other parts of the regulatory analysis, such as using the same baseline and regulatory option scenarios.
- Use the highest quality and most relevant data available. Discuss the overall quality and main limitations of the data.
- Identify relevant population groups of concern and discuss available evidence of factors that make them vulnerable to adverse effects (e.g., unique pathways; cumulative exposure to multiple stressors; behavioral, biological, or environmental factors).
- Consider unique pathways for individuals that rely on cultural or subsistence practices and relevance for Tribal or Indigenous populations, when practicable.
- Carefully select and justify the choice of comparison population group.
- Carefully select and justify the choice of the geographic unit of analysis and discuss any challenges or aggregation issues related to the choice of spatial scale.
- Analyze and compare effects in baseline and across policy scenarios to show differences in effects.
- Present summary metrics for each population group and the comparison population group and characterize differences between them.
- When data allow, characterize the distribution of risks, exposures, or outcomes within each population group, not just average effects.
- Disaggregate data to reveal important spatial differences (e.g., demographic information for each source/place) when feasible and appropriate.
- Clearly describe data sources, assumptions, analytic approaches, and results.
- Summarize the main conclusions of differences in exposure or health risk between analyzed population groups based on the available evidence.
- Discuss key sources of uncertainty or potential data biases (e.g., sample size, proximity as a surrogate for exposure) and how they may influence the results.
- When possible, conduct sensitivity analysis for key assumptions or parameters that may affect findings.
- Qualitatively describe behavioral responses not accounted for in the analysis that could affect the level or distribution of exposure or health risks (e.g., dynamic spatial or temporal effects, averting or adaptive behavior).
- Make elements of the EJ analysis as straightforward and easy for the public to understand as possible.

When data and methods allow, an EJ analysis can also examine the distribution of effects for each regulatory option – different configurations of the regulatory action being considered. This analysis is based on a prediction of the state of the world under the regulatory options. For the analysis of EJ concerns, analysts are encouraged to examine how the exposure, risk of health or environmental effects, or other outcomes of the regulatory action are distributed across population groups for the regulatory options being considered, where practicable. The EJ analysis can then evaluate the change in the exposure or risk of relevant environmental and health effects for each regulatory option compared to the baseline. In addition to identifying whether the regulatory action is expected to exacerbate, mitigate, or leave baseline EJ concerns unchanged, the analysis should shed light on the extent and distribution of these changes.

With these three sets of information – effects in the baseline, effects under the regulatory options, and a comparison of the two –analysts can characterize the distribution of environmental and health effects associated with a regulatory action, thus answering all three EJ analytic questions.

Note that a constant reduction in risk or exposure across population groups will likely not mitigate EJ concerns if there are differences in baseline environmental quality or health risk across population groups or communities (Maguire and Sheriff 2011). Conceptually, an EJ concern is only completely mitigated when there is no difference in the distribution of effects across population groups for the regulatory options being considered – i.e., everyone is experiencing the same environmental quality or health risk post-regulation.

10.2.5 Data and Information to Assess EJ Concerns

In general, the type of analysis that can be conducted depends on the availability and quality of data. In some cases, spatially resolved, individual-level data may be most appropriate and relevant for an analysis of EJ concerns. In other cases, distance from a regulated source may be the best available metric. At times, the best available information may be qualitative, including local knowledge from affected communities and Tribes (e.g., Indigenous Knowledge, also referred to as Traditional Ecological Knowledge). In all cases, analysts should use the highest quality and most relevant data and information.

When data are missing or incomplete, it is recommended that analysts document what specific types of data are unavailable or of insufficient quality, including but not limited to cases where the data are available but not of the desired granularity (spatially or temporally) and/or available for only subsets of the population. Text Box 10.2 illustrates how data quality may affect the level of analysis.

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

- Demographic and socioeconomic characteristics (e.g., race, ethnicity, income);
- Location of pollution sources (e.g., latitude/longitude coordinates, zip code, county);
- Historical, current, and projected emissions or concentrations of stressor(s) relevant to the regulatory action;
- Prevalence of specific exposure pathways that may increase risk for some population groups;
- Health effects (e.g., hospital and emergency admissions, race and ethnicity-stratified mortality rates, race and ethnicity-stratified asthma or other morbidity rates);
- Other environmental or non-environmental stressors that may be risk- or effect modifiers (e.g., indoor air concentrations, vulnerability to effects of climate change);
- Risk coefficients stratified by population groups of concern (e.g., race, ethnicity, income); and
- Distribution of economic costs, when relevant (see Section 10.x).

Text Box 10.2 - Data Quality and Spatial Resolution in the Context of Air Quality Regulations

Analysts' ability to address how a regulatory action changes the distribution of risk across population groups depends on the quality and spatial resolution of the data available. Finer-scale air quality, health, and demographic data allow one to assess the distribution of effects across population groups and to have greater confidence in the conclusions drawn from these data. When air quality data are lacking or only available at a coarse level, the ability to assess change in risk across populations and other conclusions is more limited.

An example in limited data environments: Using race-stratified county-level mortality and morbidity data, analysts can calculate population-weighted mortality rates by county. Analysts can then use a highly aggregated baseline air quality modeling projection (e.g., 12 or 36 km) to identify population groups most exposed to air pollution. Using geospatial tools, it is possible to combine the two sources of data. The coarse geographic scale of air quality information may inhibit the analyst's ability to detect meaningful differences in effects among and between groups. When risk coefficients are unavailable, it is not possible to estimate health effects separately for each population group.

An example in data-rich environments: Using finely resolved air quality data, analysts can identify at a highly disaggregated level (e.g., 1 km) population groups that experience the highest exposure to air pollution. Analysts can also identify population groups that exhibit the highest baseline incidence or prevalence rates for air pollution health effects. Using geospatial tools, analysts can spatially combine the two data sources. Using race-specific or standard risk coefficients analysts can then estimate health effects for each population group.

Three types of information are frequently used as inputs into an EJ analysis: demographic and socioeconomic data, emission data for regulated sources, and data on pre-existing health conditions or other factors that may increase an individual's vulnerability when exposed to releases from regulated sources. The U.S. Census Bureau is the recommended source for demographic and socioeconomic data in an EJ analysis. It produces several national-level data products that report demographic and socioeconomic characteristics at relatively fine spatial scales (e.g., census tract, block group), including the decennial Census, the American Community Survey (ACS), and the American Housing Survey (AHS). See Section 6.3 of the EJ Technical Guidance (U.S. EPA 2024a) for a detailed discussion of these and other sources of data and information to assess EJ concerns.

10.2.6 Analytic Methods

A variety of scientifically defensible methods can be used to assess EJ concerns associated with regulatory actions. The choice of analytic method is most often driven by data availability. Analysts may also rely on a combination of methods when analyzing a regulatory action. The conclusions that can be drawn from the analysis will vary depending on the method used. See the *EJ Technical Guidance* (U.S. EPA, 2024a) for a discussion of specific analytic methods and their relative advantages and limitations when evaluating EJ concerns.

Considerable uncertainty may exist about key relationships and health outcomes, such as how a reduction in emissions or other types of releases from a given source translates into ambient environmental quality and how it, in turn, translates into the human health effects of interest. This is particularly problematic if uncertainties differ across population groups. For instance, if an overexposed population group is more responsive to exposure (i.e., individuals in the group experience greater adverse health effects per unit of exposure), then using exposure alone as a proxy will underestimate the health risk posed by a stressor to that group. On the other hand, if proximity to a pollutant source does not correlate with exposure, it could overstate potential differences in health risk. Analysts should select the method that is most appropriate for the available data, recognizing time and resource constraints.

Regardless of the analytic approach used, the EJ analysis should be presented in a transparent way and include the following:

- Information about the specific population groups and individuals affected by the regulatory action;
- Main exposure pathways and expected health and environmental outcomes;
- Evidence for why risk, exposure, or outcomes may vary by population group, including the role of other relevant environmental and non-environmental stressors;
- Relevant geographic scale;
- Descriptions of the main methods of analysis used;
- Descriptions of key data or modeling assumptions;
- Summary statistics for the baseline and each regulatory option (both the mean and distribution) by population group;
- An easy-to-understand description of what the summary statistics show;
- Conclusions based on the information available;
- Sensitivity analysis to examine the robustness of results across options presented; and
- Data quality, key sources of uncertainty, and limitations that affect conclusions regarding potential differential effects.

Analysts should follow best practices appropriate to the questions under consideration (see Text Box 10.1). If it is not feasible to follow a particular best practice, analysts should explain why this is the case.

10.2.7 Analytic Considerations

Regardless of the analytic approach taken, analysts make a number of key decisions that can have a substantial effect on the results of the analysis, including: the geographic and temporal scope of the analysis; how to specify the comparison population group; how to spatially identify and aggregate effects across affected and unaffected populations; whether to conduct analysis from a community and/or facility perspective; and how to evaluate underlying variability, including the potential for hotspots.

An important general strategy in analyzing EJ concerns is the use of sensitivity analysis. Due to the uncertainties associated with the analytic decisions discussed below, sensitivity analysis around key assumptions is often critical for clearly communicating results to the public.

10.2.7.1 Geographic and Temporal Scope

The geographic scope of analysis for an EPA regulatory action is often the entire United States since requirements typically apply nationwide. However, in some cases the effects of a regulatory action are expected to be concentrated in specific regions or states. In such cases, it may make sense to analyze and present differences in health and environmental outcomes across population groups at both a national and a sub-national level. Because the geographic scope can affect the results of the analysis (Baden et al., 2007), analysts should make certain that the scope is relevant for the regulatory action under consideration. In addition, it is important to keep in mind that differences in health and environmental outcomes in one region or state may not necessarily hold in other regions or states.

It may be important to evaluate regulatory action effects on both shorter and longer time horizons. For instance, while a regulatory action may result in near-term reductions in emissions, changes in health and other risks may occur on a longer timeframe. In some cases, effects may even be felt intergenerationally (e.g., climate change) and the analysis may accordingly extend beyond the current generation to include a robust discussion of far-future health effects and costs. In general, the period of time over which the analysis is conducted should also be consistent with other parts of the regulatory analysis.

The scope of the analysis should generally match the scope used in other parts of the regulatory analysis (e.g., benefit-cost analysis). However, in some situations, using a different time horizon or spatial scale may be appropriate when considering EJ. For example, phasing in of regulatory requirements or relocation of polluting activities in response to the regulatory action may result in EJ concerns due to effects that occur on a time horizon or spatial scale that differs from other effects considered in the regulatory analysis. If such situations arise, analysts should clearly articulate the reasons for considering an alternative time horizon.

Another aspect of characterizing temporal scope is adequately anticipating the long run dynamic effects of a regulatory action (Cain et al., 2024). The literature uses spatial sorting models to examine how regulations may affect residential location choice but typically focuses on a specific city or region (e.g., Kuminoff et al., 2015; Redding and Rossi-Hansberg, 2017).[13,14] Spatial sorting can occur when improved environmental quality is capitalized into housing values, attracting higher-income households and shifting renters and lower-income households to less expensive neighborhoods with lower environmental quality (Melstrom and Mohammadi, 2022). On the other hand, some residents may be more likely to move into high-risk zones due to differences in housing prices (Bakkensen and Ma, 2020). Given the challenges of modeling these types of effects on a national scale, it is recommended that analysts qualitatively discuss possible household responses based on the available literature, while acknowledging the limitations of the analysis.

10.2.7.2 Comparison Population Group

To evaluate differences in effects for population groups of concern, results need to be presented relative to another group, typically referred to as a comparison population group. How the comparison population group is selected has important implications for evaluating differences in health, risk, or exposure effects across population groups of concern. It is possible to define the comparison population group as individuals with similar socioeconomic characteristics in areas of the state, region, or nation unaffected by the regulatory action (i.e., within-group comparison) or as individuals with different socioeconomic characteristics within the affected areas (i.e., across-group comparison).

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13 One exception is Fan, et al (2018). They link spatial sorting and economy-wide models of the United States to explore where people migrate in response to increased risk of extreme temperatures, while accounting for wage and housing price feedbacks.

14 Likewise, while hedonic price methods may be useful for demonstrating how changes in environmental quality factor into housing prices, predicting the effect of such price changes on household migration by race or income may be infeasible.

Analysts should aim to define the comparison population group for an across-group comparison as similar as possible to the population group of concern, but without the socioeconomic characteristics defining the group of concern. For example, analysts could compare the proportion of low-income households within areas affected by the regulatory action to the proportion of non-low-income households within the same affected areas. If analysts have fate-and-transport information on emissions, they can compare the average concentrations faced by low-income households within the affected areas to those faced by non-low-income households living in the same areas. Thus, the results from an across-group comparison indicate how the likelihood of risk or exposure within the affected areas varies with demographic and socioeconomic characteristics.

A within-group comparison compares the likelihood of risk or exposure for a specific demographic or socioeconomic group in affected areas to the likelihood of risk or exposure for that same demographic or socioeconomic group elsewhere. Again, analysts should aim for the comparison group to be as similar as possible to the population group of concern but without the risk or exposure of interest. For example, analysts can compare the proportion of low-income households within areas affected by the regulatory action to the proportion of low-income households in unaffected areas. Similarly, if analysts have information on the fate and transport of emissions, they can compare the average concentrations faced by low-income households within the affected areas to those faced by low-income households living in areas unaffected by the regulatory action.

If a regulatory action is expected to differentially affect populations within a given area (e.g., communities living near regulated facilities or in a specific region), then a combination of within- and across-group comparisons can demonstrate whether there are differences between specific population groups of concern and the general population. In some contexts, it may make sense to define the comparison population group at a sub-national level to reflect differences in socioeconomic composition across geographic regions. See Section 6.5 of the *EJ Technical Guidance* (U.S. EPA, 2024a) for a more discussion of selecting the appropriate comparison group.

10.2.7.3 Spatial Identification and Aggregating Effects

The spatial distribution of health and welfare outcomes is a relevant consideration for some regulatory actions, such as those that reduce emissions from point sources that have fairly localized effects or when there is a differential distribution of associated health or environmental effects. In other cases, the regulatory action's effects may be more widespread, and spatial distribution is less relevant (e.g., when exposure to a chemical substance depends on its purchase, use, transport, or disposal).

When exposures, risks, or human health effects are spatially distributed, analysts need to determine how to spatially identify affected and unaffected populations. The nature of the stressor(s) should guide analysts' choices of the geographic area of analysis. Some air pollutants, for example, may be emitted out of tall stacks and travel long distances, affecting individuals hundreds of miles away from the sources and thereby making it appropriate to choose a relatively large geographic area. In contrast, water pollutants or waste facilities may have more localized effects, making it appropriate to select relatively small areas for analysis. Likewise, an assessment of local effects from point sources – including possible traffic, odors, and noise implications from changes in production – may call for more spatially resolved data than those that affect regional air quality.

Complications can arise when the spatial resolution of the analysis is either too refined or too coarse. See the *EJ Technical Guidance* (U.S. EPA, 2024a) for a discussion of these challenges. Analysts are encouraged to discuss the approach used to create buffers and aggregate geospatial data, as what is most appropriate will vary with the stressor(s) affected and data used in the analysis, and to provide a transparent justification of their choice. In some cases, it may be helpful to consider multiple buffers to evaluate the effects of a regulatory action, for instance, because of uncertainty regarding fate and transport of a specific environmental stressor or because the regulatory action affects environmental stressors that travel different distances.

10.2.7.4 Facility vs Community-Based Perspectives

Exposure to other environmental and non-environmental stressors can increase the vulnerability of individuals or population groups to negative health effects from exposure to a specific environmental hazard. While explicit modeling of these interactions is often not feasible, analysts can shed light on this issue by evaluating and presenting results using not only a facility, but also a community-based perspective.

An analysis with a facility-based perspective primarily considers who may be exposed to sources regulated by the specific action under consideration. For example, such an analysis would examine proximity, emissions, concentrations, or risk associated with each regulated source in conjunction with the demographic and socioeconomic characteristics of those most likely to be exposed.

However, communities may be affected by multiple sources of pollution relevant to characterizing risk for a specific regulatory action. An analysis that takes a community-based perspective considers proximity, emissions, concentrations, or risk to a given community from multiple nearby sources of pollution to which individuals are exposed, accounting for the possibility that certain communities face increased vulnerability due to a greater number of nearby pollution sources.

10.2.7.5 Evaluating Underlying Variability and Identifying Potential Hot Spots

In addition to presenting aggregate results for population groups of concern affected by the regulatory action, it is important to understand the extent to which there are heterogeneous effects, both within specific population groups as well as across communities, given that communities often vary widely in the risks they face from the affected sources as well as from other environmental and non-environmental stressors. When data allow, analysts should characterize the distribution of risks, exposures, or outcomes within each population group of concern, not just average effects, with particular attention paid to the characteristics of populations at higher risk of exposure. When relying on proximity-based analysis, differentiating results by key facility characteristics that may be correlated with risk (e.g., plant age, capacity, production levels, accident history, types of chemicals stored on site) can be useful.

It is also important to evaluate the potential for hot spots, with particular attention paid to the communities in the upper end of the distribution of exposure or risk. Hot spots refer to geographic areas with higher levels of localized concentrations of emissions from one or more sources within a larger geographic area with more "normal" environmental quality. Hot spots may result from baseline conditions, such as exposure to other pre-existing stressors within the community. It is also possible that hot spots may be created, exacerbated, or mitigated following a regulatory action. Relevant issues to consider may include proximity to multiple sources of pollution, specific exposure pathways, and other drivers of increased vulnerability. Qualitative or other sources of data may also help to identify specific population groups or communities where a more detailed analysis is warranted.

10.2.8 Characterizing Analytic Results

Once an EJ analysis has been conducted, analysts face choices about how to characterize and communicate the results. Analysts need to present summary metrics for relevant population groups of concern and the comparison population group and characterize the differences between them. This section discusses the way in which information from the analysis can be summarized and presented, including the choice of summary metrics, ways of displaying the results in tables, maps or other visual displays, and the distinction between statistical and policy significance when interpreting results.

10.2.8.1 Summary Metrics

Simple summary measures can be used to characterize the distribution of health and environmental effects in the baseline and for regulatory options relative to appropriate comparison population groups. Analysts should consider characterizing results of the EJ analysis using more than one type of summary metric to provide a richer picture of potential effects. For instance, relative ratios can facilitate comparisons across groups or locations because all ratios are in common units. However, without presenting information on the absolute levels of risk or exposure, it is not possible to determine if either group is at risk of experiencing a potential health effect. Analysts should also present information that communicates underlying heterogeneity in the data, such as the degree of spread in the data relative to the mean (i.e., standard deviation).

Counts of the number of sources or geographic areas where the percent of a specific population group living nearby exceeds a particular threshold (e.g., the state/national average or a specific percentile) are not recommended. Counts are hard to interpret because they do not account for differences in population size or density across geographic areas. It is more informative to display metrics that characterize the full population or risk distribution to understand the extent to which affected communities differ from the comparison group. See Section 6.6 of the *EJ Technical Guidance* (U.S. EPA, 2024a) for more discussion of summary metrics.

10.2.8.2 Displaying Results Visually

Tables, maps, and other visual displays help communicate a large amount of information in an organized way to facilitate comparisons, convey results, and support discussion. Careful thought should go into how information is presented, particularly when there are:

- Multiple comparison groups (e.g., state, U.S., rural areas);
- Different types of effects (e.g., pollutants, health effects, or other environmental metrics);
- Multiple categories of regulated facilities or types of sources;
- Many individual sources;
- Clustering of sources in specific geographic areas;
- Multiple scenarios (e.g., baseline, multiple regulatory options); or
- Sensitivity analysis around key analytic assumptions (e.g., buffer distance).

Analysts need to clearly explain how to interpret the information presented in tables, maps, or figures to properly contextualize results and guard against erroneous conclusions (e.g., a large percentage change from a small baseline value may not be a large change in absolute terms). Often more than one table is needed to present results. In addition, bolding or shading specific cells can ease navigation of a dense table of results. Table 10.1 illustrates how results for multiple types of sources and several distance buffers can be presented within a single table. This example also uses shading to indicate values above the national average.

Visually displaying information in maps or figures can also help demonstrate how sources, risks, and exposures are geographically distributed across population groups, including baseline conditions and spatial clustering of sources. Note that it can be difficult to visually discern differences between baseline and regulatory options in maps or figures unless differences are large.[15] However, differences not discernible on a map may still be important.

Additionally, it is important to consider how visual indicators can be used to characterize data uncertainty, how geographic boundaries relevant to the analytic context (e.g., watershed, state, or Tribal lands) are identified on a map, and how to select appropriate intervals for visually representing the distribution of the data. For this reason, visual displays are only suggestive of potential effects and should be accompanied by tables or other graphics that allow the reader to access the underlying statistical information.

10.2.8.3 Statistical Significance and Other Considerations

Tests of statistical significance can be used to examine whether the difference between the mean values of two groups is due to factors other than chance. This can be done for a pairwise comparison, which does not control for other factors, or via a regression approach, which allows analysts to assess the relationship between two variables while controlling for other factors.

It may also be useful to examine parts of the distribution further from the mean (e.g., quantile approaches) or to use approaches that can account for outliers, skewness or heteroscedasticity (varying levels of spread) in the data. Note that the ability to test statistical significance is predicated on having a sufficiently large sample size and, for parametric approaches, an assumed distribution (e.g., normality).

It is important to understand that a statistical difference does not necessarily indicate that the difference is meaningful from a policy perspective. For instance, analysts may find that low-income households are more likely to be located near a pollution source than wealthier households, and that this effect is statistically significant (i.e., the effect is statistically distinguishable from zero and not due to sampling error). However, the difference in likelihood between these types of households could still be quite small in magnitude. Analysts need to examine what the difference implies (e.g., how different poverty is across geographic areas), and summarize those differences in a manner appropriate for policy relevance.

15 For an overview of general mapping best practices to communicate EJ concerns, such as selecting a projection, avoiding unintentional misrepresentation, and choosing a color scale to represent values, see Stieb et al. (2019).

Table 10.1 - Example Summary Table for Proximity-Based Analysis Results

Race	Population within 1 Mile of Sites with Legacy CCR SIs	Population within 3 Miles of Sites with Legacy CCR SIs	Population within 1 Mile of Sites with CCRMUs	Population within 3 Miles of Sites with CCRMUs	U.S. Population
Asian	10.36%	4.66%	2.37%	2.82%	5.64%
Black or African American	13.47%	17.03%	8.37%	13.73%	12.53%
Native Hawaiian/Pacific Islander	.03%	.08%	.06%	.07%	.18%
Native American or Alaskan Native	.79%	.93%	.86%	.78%	.82%
Other	16.65%	15.82%	20.63%	18.94%	12.82%
White	58.47%	61.47%	67.71%	63.67%	68.01%

Ethnicity	Population within 1 Mile of Sites with Legacy CCR SIs	Population within 3 Miles of Sites with Legacy CCR SIs	Population within 1 Mile of Sites with CCRMUs	Population within 3 Miles of Sites with CCRMUs	U.S. Population
Hispanic (any race)	26.27%	22.0%	32.61%	27.02%	19.24%

People of Color	Population within 1 Mile of Sites with Legacy CCR SIs	Population within 3 Miles of Sites with Legacy CCR SIs	Population within 1 Mile of Sites with CCRMUs	Population within 3 Miles of Sites with CCRMUs	U.S. Population
People of Color	52.42%	46.31%	46.70%	46.59%	41.14%

Poverty Level	Population within 1 Mile of Sites with Legacy CCR SIs	Population within 3 Miles of Sites with Legacy CCR SIs	Population within 1 Mile of Sites with CCRMUs	Population within 3 Miles of Sites with CCRMUs	U.S. Population
Households below the poverty level	16.21%	16.11%	14.94%	14.9%	12.71%

Other Sociodemographic Factors	Population within 1 Mile of Sites with Legacy CCR SIs	Population within 3 Miles of Sites with Legacy CCR SIs	Population within 1 Mile of Sites with CCRMUs	Population within 3 Miles of Sites with CCRMUs	U.S. Population
Linguistically isolated households	9.23%	5.42%	9.38%	6.05%	4.84%
Less than a high school diploma	17.60%	14.02%	17.11%	15.57%	11.24%
Person with disability	15.53%	15.61%	14.66%	15.23%	12.70%

Source: Table 6-9. Estimated Percent of Key Sociodemographic Indicators Near Legacy CCR Surface Impoundment (SI) and CCR Management Unit (MU) Sites (U.S. EPA, 2024c).

Finally, it is important to address and characterize uncertainty. Point estimates alone do not provide information about whether estimates are robust to alternate assumptions, nor can they convey the full range of potential outcomes. When statistical analysis is used, information such as confidence intervals and variance should be presented. Sensitivity analysis can also play a role in understanding the robustness of outcomes to key assumptions. Where the analysis is sensitive to the choice of model or method used, this uncertainty should also be described. Uncertainty can also be discussed by highlighting limitations in the literature, identifying caveats associated with results, or highlighting gaps in the data. See Section 6.6 of the *EJ Technical Guidance* (U.S. EPA, 2024a) for additional discussion.

10.2.9 Assessing the Distribution of Costs and Other Effects

This section addresses when it may be appropriate to evaluate how economic costs or challenges are distributed across population groups, how compliance and enforcement may vary across regulatory options under consideration, and the evaluation of non-health effects. We refer to costs as defined Chapter 8.

10.2.9.1 Distribution of Economic Costs

Certain directives (e.g., E.O. 13175, E.O. 14008, and OMB Circular A-4) identify the distribution of economic costs or challenges as an important consideration in regulatory analysis. The economics literature also typically considers both costs and benefits when evaluating distributional consequences of an environmental policy to understand its net effects. In the context of EJ, 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 costs are unevenly distributed such that low-income households bear a larger relative share, it is possible that they may experience net costs even after accounting for environmental improvements.

Fullerton (2011) discusses six possible types of distributional effects that may result from an environmental policy: costs to consumers via change in relative product prices; cost to producers or factors of production via changes in the relative returns to capital and labor; the distribution of scarcity rents (i.e., excess benefits due to restricted nature of a good, such as pollution permits); the distribution of environmental quality improvements; temporary costs of adjustment and transition (e.g., for capital and labor); and the capitalization of environmental improvements into asset prices (e.g., land or housing values). That said, the consideration of economic costs in an EJ context may be challenging, given a lack of data and methods in many instances.

Whether to undertake an analysis of economic costs as it pertains to EJ is a case-by-case determination. It will depend on the relevance of the information for the regulatory decision at hand, the likelihood that economic costs of the regulatory action will be concentrated among particular types of households, and the availability of data and methods to conduct the analysis.[16] Analysts should coordinate with economists from the Office of Policy when evaluating the potential relevance of economic costs for EJ and the degree to which they can be discussed or analyzed.

In many cases, analysis of economic costs from an EJ perspective will not substantially alter the assessment of distributional effects for population groups of concern. For instance, often the costs of regulatory action are passed onto consumers as changes in prices or wages that are spread fairly evenly across many households. When these price changes are small, the effect on an individual

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

household also will likely be relatively small. In this case, further analysis is unlikely to yield additional insights.

However, in some circumstances further exploration of the distribution of economic costs may offer substantial insight because costs are expected to differentially affect specific population groups. For example, further analysis may be warranted when costs to comply with the regulatory action represent a noticeably higher proportion of income for some population groups; when some population groups are less able to adapt to or substitute away from goods or services with now higher prices; when changes in environmental quality or health and costs are likely to accrue to the same set of individuals; when costs are concentrated on some types of households (e.g., renters) or in specific geographic areas; when there are identifiable plant closures in or relocation of facilities away from or into communities in which population groups of concern reside and work; or when behavioral changes in response to the costs of the regulatory action leave population groups of concern less protected than other groups.

While the Agency continues to investigate ways to improve incorporation of economic costs into an analysis of EJ concerns, it recognizes that, even in cases where the information is relevant, data or methods may not exist for full examination of the distributional implications of costs. In these instances, the issue can be qualitatively discussed, and the limitations and assumptions associated with characterizing costs explained. See the *EJ Technical Guidance* (U.S. EPA, 2024a) for further discussion.

10.2.9.2 Considering Compliance and Enforcement

Evidence suggests that compliance with environmental regulations can vary widely across sources in ways that exacerbate pre-existing disparities (e.g., Allaire et al. 2018; Balazs et al. 2012; Fedinick et al. 2019; McDonald and Jones, 2018). Analysts may want to consider whether regulated sources have a history of significant non-compliance or enforcement actions taken against them under various statutes or how capacity for monitoring and enforcement may differ across communities, including those on Tribal lands. Past compliance issues may indicate pre-existing EJ concerns that warrant further investigation.[17]

Analysts are encouraged to consider differences in compliance and ease of enforcement across regulatory options in the EJ analysis. When there are pre-existing differences in risk or exposure, options consistent with applicable law that improve monitoring coverage or encourage compliance can reduce exposure in communities with EJ concerns (e.g., enhanced reporting requirements for higher risk sources). Collecting, processing, and making publicly available real-time monitoring or remotely sensed data may also be effective for enhancing public awareness and participation (U.S. EPA 2021).

10.2.9.3 Other Effects and Considerations

The distribution of non-health effects associated with environmental stressors affected by the regulatory action may also be important to consider. For instance, certain population groups may place a higher value on a cultural resource (e.g., spiritual or sacred sites). If a regulatory option affects those resources, then the groups with a higher value will experience a different effect than

17 There is also a literature that explores whether the intensity of enforcement activities for environmental regulations varies with demographics such as race and income (Konisky et al. 2021; Shadbegian and Gray 2012).

groups that do not place a value on the cultural resource. Likewise, some regulatory options may differentially affect access to specific recreational activities for some population groups.

Quantifying changes in non-health effects may be challenging. Often, data on the distribution of baseline conditions for non-health effects are not easily available or are difficult to quantify, and/or are not suitable for analyzing the effects of a regulatory action. For instance, data on some ecosystem services (e.g., cultural uses of specific ecosystems) in the United States are quite limited in availability compared to baseline health data, such as mortality incidence. Likewise, data and models to assess how various regulatory options affect non-health related endpoints may not be available.

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, 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."[18]

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.[19]

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.

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18 See https://www.epa.gov/children/epas-policy-evaluating-risk-children for the original 1995 policy and the 2013 and 2018 reaffirmation memos.

19 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 (2003) provides an overview of children's health valuation issues in applied analysis.

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.[20] 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.

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 EPA's past practices as well as various laws that the EPA administers such as the Safe Drinking Water Act Amendments. Prior to 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.[21]

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.

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20 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.

21The 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 2005a).

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.

EPA's 2005 *Guidelines for Carcinogenic Risk Assessment (Cancer Guidelines)* (U.S. EPA 2005a) 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 2005b). 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.

EPA's *Child-Specific Exposures Handbook* (U.S. EPA 2008) 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. 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 2005c).

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.[22] These considerations are highlighted in EPA's *Exposure Factors Handbook* (U.S. EPA 2011) and have led 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 EPA's document entitled *Aging and Toxic Response: Issues Relevant to Risk Assessment* (U.S. EPA 2005d).

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 EPA's Children's Health Policy applies to an EPA action and, if so, how to implement the Executive Order and/or EPA's Policy. The guide clearly integrates EPA's Policy on Children's Health with the Action Development Process and provides an updated listing of additional guidance documents.

22 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 2005d).

10.3.2.3 Economic Analysis

While these *Economic 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 2003), 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.[23] This type of information could inform the exposure assessment.

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., Arcury et al. 2021; Israel et al. 2005; Lanphear et al. 1996; Mielke et al. 1999; Pastor et al. 2006; Schwartz et al. 2015). 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.

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23 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 April 1, 2020).

Chapter 10 References

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