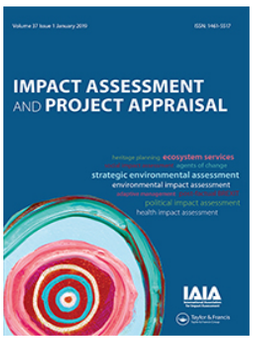

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Use and effectiveness of health impact assessment in the energy and natural resources sector in the United States, 2007 – 2016

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ABSTRACT

Decisions made in the energy and natural resources sector can affect public health. This report reviews the characteristics and assesses the effectiveness of health impact assessments (HIAs) conducted in this sector. A total of 30 HIAs conducted in 14 states in the United States were identified using a targeted literature search. Five HIAs illustrative of the different source and sub-sector categories, and with identifiable impacts on decision-making processes were selected for review. An existing conceptual framework (Wismar) was used to assess the effectiveness of the five selected HIAs on decision-making related to non-renewable energy, renewable energy, mining, and energy conservation. The 30 HIAs were performed for a variety of projects and assessed health impacts ranging from metabolic disorders to community livability. Eight of the 30 reports were incorporated into environmental impact assessments. All five selected HIAs were generally effective and raised awareness of the health effects of the projects being assessed; four were directly effective and led to changes in final project decisions. Their variable effectiveness may be related to the extent of community engagement and consideration of equity issues, differences in the details and quality of monitoring and evaluation plans devised as part of the HIA process, and whether the outcomes of monitoring and evaluation are reported.

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Health impact assessment; energy and natural resources; Wismar framework; decision-making effectiveness; United States

1. Introduction

The energy and natural resources sector in the United States (U.S.) primarily comprises renewable and non-renewable energy sources as well as non-fuel minerals (Department of Energy 2018; United States Geological Survey 2018; U.S. Energy Information Administration 2018b). The U.S produces energy mostly from non-renewable sources and consumes energy in the form of electricity across industrial, commercial, transportation, and residential sectors. Non-renewable sources of energy include oil and petroleum products, natural gas, hydrocarbon gas liquids, coal, and nuclear energy. Renewable sources of energy include hydroelectric power, biomass, biofuels, wind, geothermal, and solar energy. In 2016, non-renewable sources accounted for 89% of the energy production in the U.S, while 11% came from renewable energy sources (U.S. Energy Information Administration 2018). Furthermore, the U.S. is the world's leading producer of non-fuel natural resources such as beryllium, soda ash, and sulfur, and the third largest producer of gold and copper (Department of Energy 2018).

Health effects related to producing, distributing and consuming non-renewable and renewable energy sources, as well as extracting, processing and distributing naturally occurring minerals are wide-ranging. In the past decade, there has been an increase in natural gas production in the U.S. primarily due to more efficient extraction with hydraulic fracturing technology (Vidic et al. 2013; Chen et al. 2014; Moore et al. 2014; Werner et al. 2015). Health impacts associated with hydraulic fracturing include those resulting from surface and groundwater contamination, poor air quality from pollutant air emissions, noise pollution, traffic-related incidents, socioeconomic and psychological impacts, and occupational health hazards (Finkel and Law 2011; D'Andrea and Reddy 2014; Roundtable on Environmental Health Sciences, Research, and Medicine et al. 2014; Rabinowitz et al. 2015; Finkel 2016). In petroleum production, major oil spills have had adverse health consequences including psychological distress, hematologic and liver function abnormalities, and elevated blood hydrocarbon levels (D'Andrea and Reddy 2014; Drescher et al. 2014; Rung et al. 2015; Wilson et al. 2015; Sammarco et al. 2016). Furthermore, physical and chemical hazards pose occupational health risks to workers in oil and gas production, and mining industries (Donoghue 2004; Niven and McLeod 2009). All stages of coal extraction, transport, processing, and combustion can affect human health and well-being (Goldby and Lester 2005; Chadderton et al. 2011; Epstein et al. 2011; Morrice and Colagiuri

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2013). Many of these effects are related to particulate matter and toxic substances generated during coal production and include coal mine dust lung disease, asthma exacerbations, cardiovascular conditions, and psychological distress (Goldby and Lester 2005; Chadderton et al. 2011; Petsonk et al. 2013). Health effects of renewable energy sources remain less clear. For instance, the health effects associated with noise exposure from wind turbines have been inconclusive; while some studies have demonstrated undesirable health impacts such as poorer sleep quality, and visual annoyance, others have not (McCunney et al. 2014; Schmidt and Klokker 2014; Feder et al. 2015; Kageyama et al. 2016; Michaud et al. 2016; Jalali et al. 2016a; Jalali, Nezhad-Ahmadi, et al. 2016). Given these potential health consequences, policy and operational decisions made by industries involved in the production and distribution of energy and natural resources can impact public health.

The guiding principles of health impact assessment (HIA) are rooted in the HIA Gothenburg Consensus Paper (GCP) of 1999 (European Center for Health Policy (ECHP) 1999). Because the HIAs reviewed in this study were all performed in the U.S., the HIA definition put forward by the National Research Council was used: 'A systematic process that uses an array of data sources and analytic methods and considers input from stakeholders to determine the potential effects of a proposed policy, plan, program, or project on the health of a population and the distribution of those effects within the population. HIA provides recommendations on monitoring and managing those effects' (National Research Council (US) Committee on Health Impact Assessment 2011). HIAs follow a six-step procedure which includes: *screening, scoping, assessment, recommendations, reporting*, and *monitoring and evaluation* (National Research Council (US) Committee on Health Impact Assessment 2011). This differs slightly from HIA procedure based on the GCP which follows a five-step process: *screening, scoping, appraisal, reporting, and monitoring* (European Center for Health Policy (ECHP) 1999). In the five-step process, recommendations are made during the *reporting* step, and *monitoring* encompasses both monitoring and evaluation (European Center for Health Policy (ECHP) 1999). Factors that increase HIA success include carefully choosing a project or policy to examine; selecting an appropriate team to conduct the HIA; engaging stakeholders and decision-makers throughout the process; making clear, actionable recommendations; delivering timely, compelling messages to appropriate audiences; and using multiple dissemination methods (Bourcier et al. 2015; Dannenberg 2016).

Although the tools and principles that define HIAs are well established, there is variability in implementing HIAs across industries, regulatory agencies, and academia (Bourcier et al. 2015; Haigh et al. 2015; Dannenberg 2016; Watterson and Dinan 2016). The National Environmental Policy Act of 1969 (NEPA) established a framework for protecting the environment by requiring environmental impact assessments (EIAs), in the form of environmental assessments or environmental impact statements (EISs), for proposed federal activities (U.S. Environmental Protection Agency 2018). Although NEPA objectives and regulations include the protection of health and human welfare, human health impacts are rarely considered or implemented in current EIA practice (Bhatia and Wernham 2008; National Research Council (US) Committee on Health Impact Assessment 2011). Nonetheless, national expansion in the use of HIAs over the past two decades has catalyzed increased integration of health impacts into EIAs (Bhatia and Wernham 2008; Dannenberg et al. 2008; Bourcier et al. 2015). Variability in implementing HIAs likely arises from challenges associated with balancing the needs of society and industry with protecting the public's health; access to funding and expertise; community stakeholder participation; and issues related to transparency, scientific bias, and reproducibility (McCallum et al. 2016).

Variability in HIA implementation yields differences in HIA effectiveness (McCallum et al. 2016; Watterson and Dinan 2016). A number of frameworks for evaluating HIAs have been developed and were considered for this study (Parry and Kemm 2005; Wismar M et al. 2007; Harris-Roxas and Harris 2013). Criteria that were used for determining which framework to apply to the HIA case studies reviewed in this study included a specific focus on effectiveness as it pertains to influencing decision-making processes, as well as ease of application of the framework.

Parry and Kemm (2005) developed a framework for evaluating HIAs through discussions during a 2-day workshop involving HIA experts. This framework comprises three domains: *prediction* (predicting the consequences of different decisions), *participation* (involving stakeholders), and *informing the decision-makers*. Each domain in this framework has process and outcome criteria. Although this framework examines the degree to which decision-makers feel they have been informed by the HIA, it does not specifically address whether or how being informed influences decision-making outcomes (Parry and Kemm 2005). Furthermore, evaluations that have employed this framework have noted challenges with assessing the broad range of potential HIA impacts and demonstrating benefits to decision-making outcomes (Ali et al. 2009; Harris-Roxas and Harris 2013).

Wismar et al. (2007) of the European Observatory on Health Systems and Policies developed a conceptual framework that categorizes the effectiveness of HIAs in influencing decision-making. This framework was developed using a mapping exercise and effectiveness analysis of 17 HIAs performed in European countries, spanning several sectors and topics (Wismar et al. 2007). The mapping exercise was used to determine

the 'use, implementation and institutionalization' of HIAs, while the effectiveness analysis assessed the capacity of HIAs to affect a pending decision. Based on the effectiveness analysis, HIAs were placed into the following categories of effectiveness: *direct effectiveness* (leads to changes in decision), *general effectiveness* (raises awareness but results in no specific changes in decision), *opportunistic effectiveness* (favorable decision would have been made anyway), and *ineffective/no effectiveness* (HIA ignored or dismissed in decision). Of note, an HIA can fall into several categories of effectiveness related to decision-making outcomes in this framework (Wismar et al. 2007).

This framework also identified three dimensions of effectiveness based on considerations that played important roles in the decision-making process: *health effectiveness* (avoiding negative and strengthening positive health effects in the decision-making process), *equity effectiveness* (having a positive impact on disadvantaged members of a community in the decision-making process), and *community effectiveness* (acknowledging community interests and incorporating community participation in the decision-making process) (Wismar et al. 2007). Effectiveness of HIA for outcomes was not included in this framework primarily given the long latency of health effects, changing characteristics of affected populations, and confounding factors making outcome-based effectiveness analyses challenging (Wismar et al. 2007). This framework acknowledges that there are different types of effectiveness while providing a systematic way of categorizing how HIAs influence decision-making specifically. Although there is no clearly defined hierarchy among categories, and any given HIA can fall into several categories, the framework has been useful for guiding evaluations of impacts of HIAs on decision-making (Wismar et al. 2007; Dannenberg et al. 2008).

The third conceptual framework considered for assessing HIA effectiveness was developed by Harris and Harris-Roxas (2013) through literature review, review of work from a major HIA capacity building project, and in-depth review of HIAs. The framework proposes three key domains in evaluating the effectiveness of HIAs: *context, process,* and *impact*. It further posits that it is not possible to discuss the impacts of HIAs independent of the context in which they are conducted and the process they follow. This framework attempts to capture the wide range of factors that can determine HIA effectiveness and has a much broader conceptualization of effectiveness that includes proximal and distal, as well as direct and indirect impacts (Harris-Roxas and Harris 2013). Although this framework allows for better conceptualization of the contexts within which HIAs occur and the processes followed in HIA implementation, it does not allow for straightforward characterization of how HIAs specifically influence decision-making outcomes.

On review of these three frameworks for evaluating HIA effectiveness, the Wismar framework was chosen for its ease of use and focus on HIA effectiveness as it pertains to influencing or changing decisions (Wismar et al. 2007). This report reviews HIAs completed in the energy and natural resources sector in the U.S. between 2007 and 2016. It then assesses how these HIAs influenced decision-making processes by applying the Wismar framework to five case studies.

2. Methods

A targeted, two-step search approach was employed in reviewing the literature for HIAs performed in the energy and natural resources sector. In the first step the following web sources for published HIAs were reviewed: the Robert Wood Johnson Foundation/Pew Charitable Trusts Health Impact Project (The Pew Charitable Trusts 2018); the University of California, Los Angeles Health Impact Assessment Clearinghouse Learning and Information Center (UCLA 2014); the Society of Practitioners of Health Impact Assessment Resource website (Society of Practitioners of Health Impact Assessment (SOPHIA) 2017); the Centers for Disease Control and Prevention Healthy Places website (Centers for Disease Control and Prevention 2016); and the Human Impact Partners list of completed HIA projects (Human Impact Partners 2017). These databases were searched because they are where most HIA descriptions and reports performed in the U.S. are likely to be found.

In the second step, an internet search of PubMed, Google, and Google Scholar was conducted using the key word 'health impact assessment' sequentially paired with the following AND 'natural resources', 'energy', 'oil', 'petroleum', 'gas', 'natural gas', 'hydrocarbon gas liquid', 'coal', 'nuclear', 'uranium', 'non-renewable', 'renewable', 'wind', 'hydropower', 'biofuel', 'biomass', 'geothermal', 'solar', and 'mining'. This second step was performed to ensure that HIAs performed in the energy and natural resources not captured within the aforementioned databases were not missed. The HIAs were included in the study if they met the following criteria:

(i) The HIA (including generic assessment of health impacts, technical health impact assessment overviews, project or sector-specific HIAs including those nested within EIAs) had at minimum the following components of the HIA framework clearly defined and implemented: scoping, assessment, recommendations, and reporting.
(ii) The HIA was conducted on a policy, plan, program, or project primarily focused on producing

or influencing production of renewable and non-renewable natural and energy resources, energy consumption or energy conservation.

(iii) The HIA was completed, with access to a written summary.

(iv) The HIA was completed in the U.S. between January 2007 and December 2016.

We focused on HIAs performed in the U.S. primarily given resource challenges associated with accessing, reviewing, comparing, and evaluating HIAs performed within broader policy frameworks and decision-making environments on an international scale. Although doing so poses a limitation, conclusions drawn from this study may nonetheless have some utility and applicability internationally.

All the HIA reports generated from the targeted, two-step search approach were reviewed in detail, and the following data extracted: title, location (city, county, state); date completed; lead group/organization; lead organization type (government agency, nonprofit, educational institution); lead author(s); decision-making level (local, regional, county, state, federal); funding type (grantee, other funding); motive for performing the HIA; HIA process description (screening, scoping, assessment, recommendations, reporting, monitoring and evaluation); HIA limitations; nature of stakeholder engagement; when the HIA was performed in relationship to the EIA (where applicable); and outcome of the HIA with regards to decision-making processes.

A total of 43 HIAs were identified. A total of 11 HIAs were still in-progress without access to written reports and were as such excluded, leaving 32 completed HIAs with written reports. Two of these HIAs were excluded for the following reasons. One of these HIAs was titled 'Health Impacts of the St. Paul Ash Borer Management plan' (Minnesota Pollution Control Agency 2015). The purpose of this HIA was to assess the human health impact of the widespread loss of ash trees in Saint Paul due to the emerald ash borer (an invasive beetle) and therefore did not fall under the umbrella of the energy and natural resources sector for the purposes of this review. The second excluded report was titled 'An Integrated Assessment for Wind Energy in Lake Michigan Coastal Counties' (Nordman et al. 2015). On full review, this was purely an integrated assessment and did not have any of the key HIA components.

The Wismar framework was then used to assess the effectiveness on decision-making of five case study HIAs: two in non-renewable energy, and one each in renewable energy, mining, and energy conservation. These five case studies had identifiable impacts on the decision-making process and were selected to illustrate different source and sub-sector categories within the energy and natural resources sector. Although HIA context and process procedures were not the focus of this study, domains of effectiveness (i.e. *health, equity, community*) from the Wismar framework were also used to guide the process of reviewing the selected HIAs (Wismar et al. 2007).

3. Results

Thirty HIAs completed in 14 states in the U.S. between 2007 and 2016 were identified. Of these 9 were conducted in Alaska, 4 in California, 3 in New Mexico, and 1 or 2 in each of the other 11 states (Table 1). Of these 30 HIAs, 7 were completed in 2007–2010, 15 in 2011–2013, and 8 in 2014–2016. Project and policy areas in this sector for which HIAs were completed included: oil and gas development, mining (coal, copper, gold, zinc, sand, and uranium), renewable energy development (biomass, solar, and wind), residential and institutional energy assistance and conservation programs, energy/electricity production (using gas and coal), as well as waste-processing and elimination (Table 1).

Investigators for the HIAs included local, state, and federal government agencies such as departments of public health, departments of health and social services, county development authorities, mining and mineral divisions, Bureau of Land Management, U.S. Department of the Interior, U.S. Environmental Protection Agency, National Marine Fisheries Service, and the U.S. Forest Service; faculty and students from schools of public health, environmental studies, and physical and environmental sciences; private consultants; and non-profit organizations (Table 1). Decision-making organizations for the HIAs included local boards of supervisors; county commissioners and health departments; state departments of natural resources, and environmental quality; federal agencies such as the Bureau of Land Management and Department of the Interior; and corporations/industries (Table 1). Some HIAs were conducted during the EIA process and incorporated into the final EIA document; others were conducted before or after the EIA (Table 1). Eight of the 30 HIAs (27%) were incorporated into EIAs (Table 1). There were also cases in which an EIA was not required or performed for the policy or project being assessed. Funding for most of the HIAs came from state or federal sources, non-profit foundations or agencies, and industry (Table 1).

The health impacts assessed included metabolic disorders (diabetes, obesity, hypertension, hyperlipidemia); cardiovascular and pulmonary diseases; food insecurity and hunger; mental health; health problems related to airborne emissions, as well as water and soil contaminants; traffic-related health hazards; injury rates; infectious diseases such as sexually transmitted

Table 1. Key characteristics of 30 energy and natural resources-related HIAs conducted in the United States, 2007 to 2016 (The Pew Charitable Trusts; UCLA).

HIA Title (Year Completed)	Location	Lead Group(s)	Integration into EIS[a]
Oil and Gas Development			
Oil and Gas Lease Sale 193 and Seismic Surveying Activities in the Chukchi Sea: Final Environmental Impact Statement (2007)	Chukchi Sea, Alaska	U.S. Department of the Interior, Bureau of Ocean Energy Management	Yes
Northeast National Petroleum Reserve Supplemental Integrated Activity Plan/ Environmental Impact Statement (2008)	North Slope Borough, Alaska	Bureau of Land Management, Alaska State Office	Yes
National Petroleum Reserve Integrated Activity Plan/Environmental Impact Statement (2008)	North Slope Borough, Alaska	Bureau of Land Management, Alaska State Office	Yes
Health Impact Assessment: Point Thomson Project (2011)	Thomson Sand Reservoir, Alaska	State of Alaska HIA Program; Alaska Department of Health and Social Services; Alaska Collaborative HIA Working Group	Yes
Health Impact Assessment for Battlement Mesa (2011)	Garfield County, Colorado	University of Colorado School of Public Health, Department of Environmental and Occupational Health	Unknown
Outer Continental Shelf Oil & Gas Leasing Program: Final Programmatic Environmental Impact Statement (2012)	Alaska: Chukchi Sea, Beaufort Sea, Cook Inlet. Gulf of Mexico: Western Gulf of Mexico, Central Gulf of Mexico, Eastern Gulf of Mexico.	U.S. Department of the Interior, Bureau of Ocean Energy Management	Yes
Arctic Outer Continental Shelf Oil and Gas Multiple Lease Sale Environmental Impact Statement (2013)	Chukchi Sea and Beaufort Sea, Alaska	National Marine Fisheries Service; Bureau of Ocean Energy Management	Yes
Health Impact Assessment of the Shell Chemical Appalachia Petrochemical Complex (2014)	Monaca, Pennsylvania	Clean Air Council	Unknown
Health Impact Assessment of an Oil Drilling Project in California (2014)	Hermosa Beach, California	Intrinsik Environmental Sciences	No
Lobos CO2 Pipeline Health Impact Assessment (2015)	Torrance County, New Mexico	Human Impact Partners; New Mexico Department of Health; Partnership for a Healthy Torrance County	No
Mining (Coal, Copper, Gold, Sand, Uranium, Zinc)			
Red Dog Mine Extension Aqqaluk Project Final Supplemental Environmental Impact Statement (2009)	Northwest Artic Borough, Alaska	U.S. Environmental Protection Agency	Yes
Pebble Mine Health Impact Assessment (2010)	Bristol Bay, Alaska	University of Alaska, Anchorage	Unknown
Health Impact Assessment of Coal and Clean Energy Options in Kentucky (2012)	Kentucky	Kentucky Environmental Foundation	Unknown
Draft Environmental Impact Statement for the Roca Honda Mine (2013)	New Mexico: Cibola National Forest; McKinley and Cibola Counties; Mount Taylor Ranger District.	U.S. Forest Service; U.S. Environmental Protection Agency; New Mexico Mining and Minerals Division; New Mexico Environment Department; New Mexico Department of Game and Fish	Yes
Health Impact Assessment for Proposed Coal Mine at Wishbone Hill (2014)	Wishbone Hill, Matanuska-Susitna Borough, Alaska	Alaska Department of Health and Social Services	Unknown
Health Impact Assessment of Industrial Sand Mining in Western Wisconsin (2016)	Wisconsin	Institute for Wisconsin's Health, Incorporated.	Unknown
Renewable Energy			
Health Impact Assessment of the Proposed Cabin Creek Biomass Energy Facility in Placer County California (2012)	Placer County, California	Sequoia Foundation; Placer County Department of Planning; Placer County Department of Health and Human Service; California Department of Health	No
Strategic Health Impact Assessment on Wind Energy Development in Oregon (2013)	Oregon	Oregon Health Authority, Public Health Division	Unknown
The Potential Health Impact of a Poultry Litter-to-Energy Facility in the Shenandoah Valley, Virginia (2013)	Shenandoah Valley, Virginia	Virginia Commonwealth University: Center for Human Needs, Center for Environmental Studies	Unknown
Mojave Desert Utility-Scale Solar Project HIA (2014)	Mojave Desert, California	The National Indian Justice Center	Unknown
Energy Production			
North Florida Power Plant Health Impact Assessment (2007)	Taylor County, Florida	Healthy Development, Incorporated; Taylor County Development Authority	Unknown
Health Impact Assessment of the Shawnee Fossil Plant (2014)	McCracken County, Kentucky	Kentucky Environmental Foundation	No
Health Impact Assessment for the Proposed Natural Gas Plant in New Orleans East (2016)	New Orleans, Louisiana	Louisiana Public Health Institute; Alliance for Affordable Energy	Unknown

(*Continued*)

Table 1. (Continued).

HIA Title (Year Completed)	Location	Lead Group(s)	Integration into EIS[a]
Energy Assistance and Energy Conservation			
Unhealthy Consequences: Energy Costs and Child Health – Child Health Impact Assessment of Energy Costs and the Low-Income Energy Assistance Program (2007)	Boston, Massachusetts	Boston Medical Center Child Health Impact Group	Unknown
School Biomass Boilers Health Impact Assessment (2011)	Oregon	Oregon Health Authority, Office of Environmental Health	Unknown
The Health Impact Assessment of the Commonwealth Edison Advanced metering infrastructure Deployment (2012)	Illinois	National Center for Medical-Legal Partnership; Citizens Utility Board; Consumer Affairs Consultant; Energy Programs Consortium	Unknown
Saving Energy, Improving Health: Potential Impacts of Energy Efficiency Program Design on Noise and Air Pollution Exposure (2013)	San Francisco, California	San Francisco Department of Public Health	Unknown
Rapid Health Impact Assessment: Weatherization Plus Health in Connecticut (2013)	Connecticut	New Opportunities Incorporated; Connecticut Association for Community Action	Unknown
Waste Processing and Elimination			
Health Impact Assessment on New Mexico Recovery Transfer's Request for a Special Use Permit (2011)	Bernalillo County, New Mexico	Bernalillo County Place Matters Team	Unknown
Health Impact Assessment Report: Assessment of Open Burning Enforcement in La Crosse County (2011)	La Crosse, Wisconsin	La Crosse County Health Department	Unknown

[a]Environmental Impact Statement.

Sources: The Pew Charitable Trusts. Health Impact Assessments in the United States (http://www.pewtrusts.org/en/multimedia/data-visualizations/2015/hia-map); UCLA. UCLA Health Impact Assessment Clearinghouse Learning and Information Center (http://www.hiaguide.org/).

diseases and respiratory illnesses; employment and job security; community livability; and child health and safety. While some of the HIAs incorporated quantitative data, most included the direction but usually not the magnitude of an effect on health. The results of the HIAs reviewed were communicated through public testimony to decision-makers and stakeholders, reports released to the media and posted on websites, and HIA findings integrated into EIA reports. At least two of the HIA reports have been published in peer-review journals (Witter et al. 2013; McCallum et al. 2016).

3.1. *Case studies on HIA effectiveness*

The decision-making outcomes of the HIAs reviewed for this report were primarily determined by examining websites of state, federal, non-profit or corporate stakeholders, as well as news media. The five case studies below had identifiable impacts on the decision-making process and were selected to illustrate different source and sub-sector categories within the energy and natural resources sector; they are therefore not necessarily representative of all HIAs in this sector.

3.1.1. *Case study 1: HIA on wind energy development in Oregon*

Wind energy is a renewable energy source increasingly harnessed for electricity production in the U.S. (U.S. Energy Information Administration 2018). In 2012, the Oregon Health Authority's Public Health Division conducted a strategic HIA to identify community concerns about potential health impacts from wind energy facilities; assess the evidence for health impacts of highest priority for stakeholders; develop evidence-based recommendations for local and state decision-makers, public health officials, the wind energy industry and community members to consider in future wind energy facility siting decisions; and engage stakeholders in the HIA process thereby increasing awareness of the use of HIAs for informing wind farm-siting decisions (Oregon Health Authority 2013). This HIA was performed within the context of Oregon's Renewable Portfolio Standard, which has influenced wind energy development in Oregon by requiring electric utilities and retail electricity suppliers to increase the proportion of electricity sold to customers that is derived from renewable energy sources (Department of Energy, Oregon 2018).

The scope of the HIA was established during community listening sessions and included five domains: noise, visual impacts, air pollution, economic effects, and community conflicts (Oregon Health Authority 2013). For each domain, key research questions were identified and a literature review performed. The HIA found that Oregon's ambient noise degradation standard for wind energy facilities was not expected to result in annoyance, sleep disturbance, or other health effects. However landowners waiving Oregon's ambient noise degradation standard could experience higher noise levels, and associated sleep disturbance and moderate to serious annoyance. For visual impacts, the low frequency shadow flicker from wind turbines was found unlikely to cause annoyance or adverse health effects, such as triggering seizures in individuals with photosensitive epilepsy. The HIA further demonstrated that reductions in regional emissions of greenhouse gases from fossil-fuel-based power plants replaced by wind energy facilities could result in decreased risk for respiratory illness, cardiovascular disease, cancer, and premature death. Wind energy development could have indirect positive economic effects in Oregon communities by increasing local employment, as well as personal and community-wide revenue. The HIA also determined that long-term stress from real or perceived environmental threats from wind energy facilities within a community could increase risks for cardiovascular disease, endocrine disorders, mental illness, and other negative health effects (Oregon Health Authority 2013).

HIA recommendations included implementing strategies to mitigate noise levels; addressing community concerns as part of the wind facility-siting process; informing residents living near wind energy facilities about potential risks and benefits associated with a development; implementing strategies to mitigate any negative effects of shadow flicker; linking the development of wind energy to reductions in fossil fuel use; instituting strategies to decrease construction-related air pollution; considering strategies to increase community-wide economic benefits; and using strategies to anticipate, understand, and manage conflict and stress in communities near proposed developments. In the process of making recommendations to mitigate negative health effects related to the development of wind energy facilities, this HIA acknowledged community interests including concerns about fairness and equity particularly related to increasing community-wide economic benefits, and engaged community participation (Oregon Health Authority 2013).

The goal of this HIA was to provide a starting point for stakeholders to understand the potential health effects associated with wind energy facilities and enable them to better determine the scope and utility of HIAs for future wind energy developments. By performing this HIA, the state health and energy agencies developed a partnership thereby streamlining health consultation for future energy development projects. Furthermore, the HIA developed evidence-based recommendations that stakeholders engaged in policy making could consider in future wind energy facility siting decisions (Oregon Health Authority 2013). Given the strategic nature and goals of this HIA, it was generally effective in setting

the stage for increasing awareness among policy makers of the health impacts of wind energy development in Oregon.

3.1.2. *Case study 2: Illinois advanced metering infrastructure deployment HIA*

In 2008, an electric utility company in Illinois servicing about 70% of the state's residents submitted a system modernization plan to the Illinois Commerce Commission (ICC) (Sandel M et al. 2012). This plan included investments in advanced metering infrastructure (AMI) – an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers (Sandel et al. 2012; U.S. Department of Energy 2015). The ICC requested additional information regarding costs and benefits of developing AMI. After installing the new metering system in 2009, the electric utility company implemented a Customer Applications Pilot program to develop project goals, timelines, evaluation criteria, and technology selection criteria for up to 150,000 m throughout its service territory. The HIA was performed by the National Center for Medical-Legal Partnership to provide health-related information pertinent to AMI deployment.

Research methods employed in the HIA to determine the health impacts of the pilot project included: literature review; analysis of existing datasets to develop health profiles for the affected geographic areas; review of primary data from the utility company of customers participating in the AMI pilot; and surveys to capture the experiences of low-income households. The health impacts assessed included those related to fuel poverty – the inability of a household to afford essential electricity or other energy needs; unintentional injuries and premature deaths from disconnected service; as well as temperature-sensitive chronic conditions made worse by heat or cold (Sandel et al. 2012).

The HIA found that fuel poverty was strongly associated with a diminished capacity to purchase basic necessities such as food, resulting in poor nutritional status particularly among children and the elderly. Fuel poverty also decreased access to health care and had a negative effect on housing quality for some households. Being remotely disconnected for not paying electricity bills was strongly associated with not having access to electrically powered medical devices (such as sleep apnea machines and nebulizers). Use of alternative and often risky sources of light and heat in the event of remote disconnection increased the risk of carbon monoxide poisonings, residential fire injuries, and related deaths. The HIA further found that decreased access to cooling and heating was associated with a higher risk of heat- and cold-related illness particularly among children, the elderly, disabled, adults without social support, and individuals with chronic diseases (Sandel et al. 2012).

HIA recommendations included incorporating health and safety impacts on vulnerable residential customers into the analysis of the proposed terms of AMI deployment; promoting consumer education and outreach to generate awareness of approved programs; and deploying the remote connection and disconnection functionality in a manner that did not endanger the health of vulnerable customers. The HIA also proposed a monitoring plan which included a summary of health impacts, a description of mitigation measures and policy recommendations, tracking and publicly reporting AMI implementation measures, as well as tracking health outcomes (Sandel et al. 2012). Overall, this HIA made recommendations to mitigate the potential negative health effects of remote disconnection and fuel poverty, acknowledged community interests, and addressed equity concerns by surveying the experiences of vulnerable individuals.

The electric utility company submitted a revised AMI deployment plan to the ICC in 2012 (Commonwealth Edison Company 2012). In this plan, they included a customer outreach and education program to highlight the benefits of the new metering program such as reduced energy costs. Milestones and metrics for measuring the success of AMI and consumer benefits were also included in this plan. The ICC approved the revised plan (Illinois Commerce Commission 2012). This HIA can therefore be categorized as being directly effective to the decision-making process; although the HIA was not explicitly mentioned in the revised plan, HIA recommendations were incorporated into the plan and likely contributed to the ICC's approval. This HIA may also have had opportunistic effectiveness; approval of the revised plan may have occurred anyway given the additional information that the electric utility company provided to the ICC through the pilot program.

3.1.3. *Case study 3: HIA for proposed coal mine at Wishbone Hill, Alaska*

In 2010, the owner of the permit for mining at Wishbone Hill Mine in the Matanuska-Susitna Valley sought a permit renewal to begin operating a surface coal mine (Krieger and Anderson 2014). The renewal was for a proposed development on a 6 million ton coal reserve estimated to produce 500,000 tons of coal annually for approximately 12 years. An HIA was prepared for the Alaska Department of Health and Social Services for this development by NewFields consultants, a for-profit company that provides services to industry and is not an independent proponent of public health (Krieger and Anderson 2014; NewFields 2018). This HIA was performed using the methods described in the Alaska HIA toolkit (Krieger

and Anderson 2014; Alaska Department of Health and Social Services 2018).

Based on focus group meetings with stakeholders including local residents, health impacts in this HIA included social determinants of health; accidents and injuries; exposure to potentially hazardous materials; food, nutrition and subsistence; infectious diseases including sexually transmitted infections; chronic diseases; water and sanitation; and health infrastructure and capacity. A baseline health summary of communities that would potentially be affected by developing a new coal reserve was generated, and a literature review of key studies on community health impacts of coal mining performed. The HIA found that coal development would increase the median household income, decrease unemployment, decrease the percentage of households living below the poverty line, improve educational attainment, and lower regional food costs. The HIA also demonstrated a negative impact on morbidity and mortality related to psychosocial distress, motor vehicle traffic and motor vehicle crashes, and poor air quality associated with exacerbation of respiratory, cerebrovascular and cardiovascular diseases. Developing the coal reserve would help improve the ratio of people to health care providers, but lead to an increase in the rates of infectious diseases and also worsen morbidity and mortality from chronic diseases (Krieger and Anderson 2014).

HIA recommendations included: stakeholders remaining knowledgeable of community concerns by performing regular community engagement meetings and following best practice strategies for engaging with indigenous communities; training drivers effectively and following routine transportation safety to reduce traffic-related injuries; as well as minimizing dust production and regularly reviewing data collected by air quality and water quality monitoring stations (Krieger and Anderson 2014). Overall, this HIA acknowledged community interests by highlighting the importance of engaging with indigenous communities; addressed equity issues by demonstrating a likely decrease in the proportion of households living below poverty line; and made recommendations to mitigate the potential negative health effects related to permit approval for coal mining at the Wishbone Hill Mine.

In reviewing the final permit renewal application, the Alaska Department of Natural Resources considered the HIA findings and recommendations as they pertained to permit-related analyses under the Alaska Surface Coal Mining Control and Reclamation Act (Usibelli Coal Mine, Inc 2014). For instance, the proposed addition of new water monitoring wells was incorporated into the final approved permit. The Commissioner of the Alaska Department of Natural Resources approved the hearing officer's recommendation to renew the coal mining permit (Alaska Department of Natural Resources 2015a, 2015b). This HIA can therefore be categorized as being generally effective regarding the decision-making process. Information from the HIA was considered by decision-makers thereby likely increasing their awareness of health impacts associated with permit renewal for coal mining activities. The HIA was also directly effective in that its recommendations changed aspects of the permitting process.

3.1.4. *Case study 4: HIA of an oil drilling project in the city of Hermosa Beach, California*

An oil drilling company proposed construction of 30 oil wells on a site used as a city maintenance yard in the City of Hermosa Beach, California (McCallum et al. 2016). The majority of Hermosa Beach residents who responded to an online survey conducted to help identify community concerns were either 'very' or 'somewhat' concerned about the potential health effects of the project. The City of Hermosa Beach commissioned an HIA in 2014 to inform voters about the potential health impacts of the project. The HIA was performed by Intrinsik, an environmental and health sciences consulting company (Intrinsik 2018). An Environmental Impact Report (EIR) and cost-benefit analysis were also commissioned by the City. Residents were allowed to vote on whether or not to lift the existing oil ban and allow the project to proceed (McCallum et al. 2016).

Based on stakeholder input including that of local residents, six major health impact categories were identified: air quality, water and soil quality, adverse event scenarios, noise and light, traffic, and community livability. An evaluation matrix was developed to characterize and summarize the predicted health impacts; it included potential health outcomes associated with each category before and after implementing proposed EIR mitigation measures. Although health effects were identified for each health impact category, the post-mitigation health effects were not substantial overall. The negative health impacts identified included: odor-related effects such as stress, headaches, eye and nose irritation, cough, and nasal congestion; excess noise resulting in sleep disturbance, stress, annoyance, hypertension and cognitive impairment; and stress over property values and aesthetics. Although the probability of oil spills and blowouts was low, considerable adverse health outcomes including death could arise if spills or blowouts did occur. The HIA showed a positive effect on community livability from increased funding for recreation, green space, education, and political involvement activities. The HIA found no marked health effects related to air emissions of nitrogen dioxide, particulate matter, or other air contaminants; traffic safety and perceived hazards; surface water quality and soil particulates; or social cohesion. Overall, based on proposed

mitigation measures in the EIR and additional recommendations provided by the HIA, the authors concluded that the oil drilling project would have no substantial impact on community health in Hermosa Beach (McCallum et al. 2016).

The HIA recommended periodic monitoring of odor if reports of odors became frequent; incorporating a well blowout scenario into the City's emergency preparedness plan; written notification of local residents about impending work in anticipation of potentially elevated noise levels; provision of black-out blinds or curtains to residents more directly affected by light emissions to eliminate potential sleep disruptions; property value analysis prior to, during, and after construction, and 1 year into operations to help ensure that any fluctuations remained within expected levels (McCallum et al. 2016). Recommendations for monitoring included formation of a Community Liaison Committee to allow citizens to voice concerns about project-related activities; a follow-up Community Health Assessment to assess the health status 5 years after project operations begin; and a Quality of Life Survey to monitor health status changes during the project (McCallum et al. 2016). Overall, this HIA acknowledged and engaged community interests, and made recommendations to mitigate potential negative health effects related to construction of the oil wells.

The oil drilling and production project measure was on the ballot for Hermosa Beach voters in March 2015 and was voted against by the majority of voters (Encyclopedia of American Politics 2015). The HIA performed in this case can be described as directly effective in the decision-making process. Because of the HIA, in combination with findings and recommendations from the EIR and cost-benefit analysis, the oil drilling project was dropped. This HIA was also generally effective in that it helped to increase awareness of potential health impacts related to the oil drilling project and demonstrated how the EIR proposed mitigation measures would reduce adverse health effects.

3.1.5. *Case study 5: natural gas development in Battlement Mesa, Colorado*

In 2009, a natural gas operator announced plans to develop 200 gas wells in the Battlement Mesa census-designated community in Garfield County, Colorado (Witter et al. 2013). Given the proposed proximity of the gas wells to their homes, Battlement Mesa residents petitioned their county commissioners to perform an HIA prior to issuing permits to the natural gas operator. The board of county commissioners contracted with the University of Colorado School of Public Health Department of Environmental and Occupational Health to conduct the HIA. Technical assistance for the HIA was funded by the Health Impact Project, a collaboration of the Robert Wood Johnson Foundation and the Pew Charitable Trusts. The HIA was conducted before the natural gas development project had begun. All interested parties were invited to participate as stakeholders, including residents and citizen groups of Battlement Mesa.

Using exposure data from other local sites with natural gas development, and medical literature describing known health impacts of such exposures, the HIA characterized potential health effects associated with exposure to chemical air emissions, industrial operations, and noise pollution; changes to community character; and economic impacts. The HIA found that well development could cause significant increases in air emissions of volatile organic compounds, carbonyls, polyaromatic hydrocarbons, nitrogen oxides, and diesel exhausts leading to probable short-term health effects (such as headache, airway, and mucous membrane irritation) and possible long-term health effects (such as cancer, birth defects, and exacerbation of chronic pulmonary and cardiovascular diseases). Industrial operations were likely to increase industrial traffic on residential roads leading to a rise in traffic crashes, decreased use of walking and bicycle routes, and possible health effects of diesel exhaust exposure. Minor and major events such as spills, fires, and explosions could cause stress and anxiety, as well as health and safety effects resulting from exposures associated with these incidents. Noise pollution from drilling operations, flaring, and truck traffic could lead to noise-related stress, sleep disturbance, and possible cardiovascular effects. Finally the HIA found that a perceived decline in community livability, decreased appeal of outdoor amenities, inflow of itinerant workers to Battlement Mesa, and likely loss of property value would probably cause stress, a decline in social cohesion, and decreased access to outdoor physical activities, but was unlikely to increase rates of crime, sexually transmitted infections, or substance abuse (Witter et al. 2013).

HIA recommendations included reducing the potential for chemical exposures by using contaminant control measures such as pollution prevention, air and water monitoring, and health monitoring; reducing exposure to industrial operations by employing measures such as traffic control, industrial safety control, and industrial noise control; and supporting the residential character of the community by setting up a community advisory board, as well as performing community wellness monitoring (Witter et al. 2013). Overall, this HIA acknowledged community interests and engaged community participation, addressed equity issues pertaining to community livability and social cohesion, and made recommendations to mitigate potential negative health effects related to the development of the gas wells in Battlement Mesa.

Although a second draft of the HIA was completed, political conflicts surrounding the Battlement Mesa HIA process were such that the HIA was not finalized

(Witter et al. 2013). Nonetheless, the natural gas operator was able to obtain permits to drill *near* Battlement Mesa but not *within* the community of Battlement Mesa (Colorado Oil and Gas Conservation Commission 2018). Furthermore, this HIA has been cited in various citizen actions, as well as government and legal proceedings, as an example of a comprehensive approach to addressing public health concerns regarding natural gas development (Witter et al. 2013). This HIA can therefore be characterized as being directly effective since permits for natural gas development within Battlement Mesa were not approved. This HIA was also generally effective in that it helped to raised awareness among policy makers of the public health issues associated with natural gas development.

4. Discussion

This is the first study to review HIAs performed in the energy and natural resources sector in the U.S. and to demonstrate the variable effectiveness of HIAs to decision-making in this sector using the Wismar conceptual framework. Not surprisingly, the HIAs performed primarily pertained to projects and policies related to non-renewable energy: 16 (53%) of the HIAs were completed in oil and gas development and mining, while renewable energy HIAs made up 13% of the HIAs reviewed. Most (63%) of the HIAs in non-renewable energy were led or performed by state or federal government agencies, while those in renewable energy were primarily performed by non-profit organizations (25%), schools of public health (25%), and state departments of health (50%). Eight (27%) of the 30 HIAs were incorporated into EIAs; all of these HIAs were performed on policies or projects related to non-renewable energy.

The Wismar conceptual framework has been successfully used in other country settings to assess the effectiveness of HIAs (Wismar et al. 2007; Haigh et al. 2013). The five HIAs reviewed in this report were all generally effective because they raised awareness among stakeholders and decision-makers of the health effects of the projects and policies assessed (Wismar et al. 2007). Four of the case studies were directly effective, meaning that these HIAs either resulted in changes to the final decision (*Illinois AMI, Wishbone Hill Mine*), or led to the project or policy being dropped (*Hermosa Beach, Battlement Mesa*). Some effects were proximal, in that the HIAs informed or changed decisions (Harris-Roxas and Harris 2013). Other decision-making outcomes were distal or long term; they increased awareness of the HIA process, highlighted the importance of health to decision-making, or promoted strong partnerships among stakeholders (Harris-Roxas and Harris 2013). All five case studies demonstrated community and health effectiveness as defined in the Wismar framework; they acknowledged community interests, incorporated community participation, and made recommendations to mitigate negative and strengthen positive health effects in the decision-making progress. Four (*Oregon Wind Energy, Illinois AMI, Wishbone Hill Mine, Battlement Mesa*) case studies demonstrated equity effectiveness; they sought to have a positive impact on disadvantaged members of the community in the decision-making process.

Determining the effectiveness of HIAs on the decision-making process is complex. Proximal impacts related to immediate decisions are likely easier to analyze than long-term impacts which often require continued monitoring and evaluation strategies (Wismar et al. 2007; National Research Council (US) Committee on Health Impact Assessment 2011; Harris-Roxas and Harris 2013). In the six-step HIA process, *monitoring and evaluation* refers to examining the adoption and implementation of HIA recommendations, analyzing HIA processes and outcomes, and assessing changes in health or health determinants (National Research Council (US) Committee on Health Impact Assessment 2011). Of the five case studies reviewed, all had monitoring plans (*Oregon Wind Energy, Battlement Mesa, Illinois AMI, Wishbone Hill Mine, Hermosa Beach*), and three reported evaluation plans (*Oregon Wind Energy, Illinois AMI, Hermosa Beach*). For example, the *Illinois AMI* HIA suggested using consumer groups to track the electric utility company's progress on implementing HIA recommendations; the *Hermosa Beach* HIA planned to perform internal process and impact evaluations to determine how well the HIA fulfilled its intended purpose, and to highlight areas for improvement. Although monitoring and evaluation plans were included in these HIAs, their decision-making outcomes were primarily determined from stakeholder and news media websites. This was not unexpected since HIA reports generally do not include the results of monitoring and evaluation strategies, making it challenging to assess HIA decision-making outcomes (National Research Council (US) Committee on Health Impact Assessment 2011). Improving HIA implementation plans by including specific action items, completion time tables, and parties responsible for monitoring, evaluating, and reporting results could better streamline the complex process of tracking HIA effectiveness on decision-making outcomes.

HIAs provide a systematic way of bringing stakeholders together to determine potential health effects of proposed projects and policies, and make recommendations for timely mitigation of those effects (National Research Council (US) Committee on Health Impact Assessment 2011). As demonstrated in the case studies described, HIAs can play a key role in often complex decision-making processes by encouraging stakeholders to consider health impacts and equity concerns while engaging communities. When performed effectively,

HIAs allow stakeholders to agree on mitigation strategies that are mutually acceptable and health-promoting (Harris-Roxas et al. 2014; Bourcier et al. 2015; Haigh et al. 2015; Dannenberg 2016). HIAs may however also be viewed as barriers to implementing projects and policies, particularly given the challenge of balancing the need for energy with protecting the public's health. For projects in the energy and natural resources sector, a downstream transaction typically occurs between producers of energy or natural resources and consumers. Equity issues pertaining to the distribution of risk of negative health impacts, economic benefits, as well as decision-making may therefore arise within communities where these resources are produced, as well as between communities in which these resources are produced and communities not directly involved in the production process. In this study, three (*Illinois AMI, Wishbone Hill Mine, Battlement* Mesa) of the four case studies which demonstrated community effectiveness and equity effectiveness were also shown to be directly effective for decision-making outcomes (Table 2). Considering and addressing community and equity concerns during the HIA process could therefore improve the effectiveness of HIAs to the decision-making process.

HIAs performed in the energy and natural resources sector have helped to establish their overall value. Although NEPA guides federal decisions affecting the environment, not much attention has historically been paid to human health effects when performing EIAs (Bhatia and Wernham 2008; National Research Council (US) Committee on Health Impact Assessment 2011; U.S. Environmental Protection Agency 2018). In recent years, health effects have increasingly been analyzed in state and federal level EIAs, particularly in Alaska and California (Wernham 2007; Bhatia and Wernham 2008; Anderson et al. 2013). Alaska, for instance, has an established HIA program that evaluates potential health effects of new policies, programs, or projects using existing public health surveillance data, medical literature reviews, and field studies (Alaska Department of Health and Social Services 2018). While not required by Alaska state law, HIAs are considered part of a best practice approach for responsible development (Alaska Department of Health and Social Services 2018). One of the first federal EIAs to incorporate an HIA was performed in 2007 by the Bureau of Land Management, and evaluated a proposed plan to lease oil and gas rights in the North Slope Borough of Alaska (Wernham 2007). The Alaska Native community members in the borough made a convincing case for a more detailed health analysis. Subsequently, the

Table 2. Effectiveness of energy and natural resources case study health impact assessments on decision-making outcomes using the Wismar[a] Framework.

Case Study	Title	Wismar Framework Decision-Making Effectiveness Categories[b]	Supporting Details	Wismar Framework Effectiveness Dimensions[c]
1	HIA on Wind Energy Development in Oregon	(a) General effectiveness	(a) HIA set the stage to increase awareness among policy makers of health impacts of wind energy development in Oregon	Demonstrated health, community and equity effectiveness
2	Illinois Advanced Metering (AMI) Infrastructure Development HIA	(a) Direct effectiveness (b) Opportunistic effectiveness	(a) HIA recommendations were incorporated into the revised AMI plan likely contributing to approval by the Illinois Commerce Commission (b) Approval of the revised plan may have occurred anyway given additional information obtained through the AMI pilot program performed by the electric utility company	Demonstrated health, community and equity effectiveness
3	HIA for Proposed Coal Mine at Wishbone Hill, Alaska	(a) Direct effectiveness (b) General effectiveness	(a) HIA recommendations changed aspects of the permitting process (b) Information from the HIA was considered by decision-makers thereby likely increasing awareness of health impacts associated with coal mining activities	Demonstrated health, community and equity effectiveness
4	HIA of an Oil Drilling Project in the City of Hermosa Beach, California	(a) Direct effectiveness (b) General effectiveness	(a) Oil drilling project was cancelled because of the HIA, in combination with findings and recommendations from the Environmental Impact Review and cost-benefit analysis (b) HIA helped increase awareness of potential health impacts related to the oil drilling project	Demonstrated health and community effectiveness
5	Natural Gas Development in Battlement Mesa, Colorado	(a) Direct effectiveness (b) General effectiveness	(a) HIA contributed to the natural gas development within Battlement Mesa not being approved. (b) HIA helped raise awareness among policy makers of the public health issues associated with natural gas development	Demonstrated health, community and equity effectiveness

[a]Source: Wismar M, Blau J, Ernst K, Figueras J. (2007). The effectiveness of health impact assessment: scope and limitations of supporting decision-making in Europe. Available from: http://www.euro.who.int/__data/assets/pdf_file/0003/98283/E90794.pdf

[b]Wismar Framework Decision-Making Effectiveness Categories
- Direct effectiveness → leads to changes in decision.
- General effectiveness → raises awareness but has no specific impact on decisions.
- Opportunistic effectiveness → favorable decision would have been made anyway.
- No effectiveness → HIA ignored or dismissed in the decision-making.

[c]Wismar Framework Effectiveness Dimensions
- Health effectiveness → avoiding negative and strengthening positive health effects in the decision-making process.
- Equity effectiveness → having a positive impact on disadvantaged members of a community in the decision-making process.
- Community effectiveness → acknowledging community interests and incorporating community participation in the decision-making process.

North Slope Borough Health Department performed an HIA that was then incorporated into the final EIA (Wernham 2007). This project and similar work have established a precedent that is helping to increase the number of EIAs that incorporate HIAs (Bhatia and Wernham 2008), a trend further supported by the observation that 27% of the HIAs identified in this study were integrated into EIAs (Table 1).

HIAs are not currently a regulatory requirement in the U.S. Making health an essential and required part of decision-making in the development of energy and natural resources is particularly important to poorer communities that have limited access to the funding or expertise needed to perform HIAs. Requiring HIAs could help to systematically address disparities in health impacts resulting from implementation of projects in this sector. Doing so would also help align industry interests with national public health goals such as those delineated by the U.S. Healthy People (2020) environmental health objectives (Office of Disease Prevention and Health Promotion). Furthermore, formally incorporating HIAs into EIAs could streamline decision-making processes and outcomes. Requiring HIAs or enforcing health considerations into existing EIAs could however lead to push back from industry, especially in our current anti-regulatory environment. More work is needed to educate producers of energy and natural resources about the potential public relations, public health, and legal benefits associated with performing HIAs.

4.1. *Limitations*

This review has several limitations that should be considered in the interpretation of its findings. Some relevant HIAs may not have been included because they were not identified as HIAs in their titles or text, available on the web, or publicly accessible. Also, although the case studies illustrated different areas within the energy and natural resources sector, they were chosen from among those known to have clearly identifiable decision-making outcomes and do not represent the range of decision-making outcomes for all HIAs in this sector. Finally, although HIAs are used in this sector in other parts of the world (Drewry and Kwiatkowski 2015), HIAs performed outside the U.S. were not reviewed, therefore potentially limiting the generalizability of the findings and conclusions of this report.

5. Conclusions

HIAs provide a systematic way of bringing stakeholders together to determine potential health effects of proposed projects and policies, and make recommendations for timely mitigation of population health impacts. Most of the HIAs performed in the energy and natural resources sector fell under the umbrella of non-renewable energy projects and policies. HIAs performed in this sector have variable effectiveness to decision-making outcomes based on the Wismar framework, but remain valuable to influencing decisions. The variable effectiveness of HIAs to the decision-making process may be related to the extent of community engagement as well as consideration of equity issues when making recommendations for mitigating negative and strengthening positive health effects; differences in the details and quality of monitoring and evaluation plans devised as part of the HIA process; and whether the outcomes of monitoring and evaluation are reported. As HIAs are more widely used in this sector in the U.S., more work is needed to document the impacts of the HIAs on decision-making processes and outcomes. Furthermore, increasing the use of HIAs could help make health an essential part of decision-making processes in the energy and natural resources sector.

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