SSHRC Imagining Canada's Future

Knowledge Synthesis:

Energy and Resources

Children and Youth's Biopsychosocial Health in the context of Energy Resource Activities

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Key Messages

1. *The effects of energy activities on children and youth have been largely overlooked*. This review has revealed that relatively few studies have investigated the effects of energy systems on the biopsychosocial health of children and youth. This is a particularly important area of study, given the short and long-term physical and mental health implications associated with young people's increased vulnerability to environmental hazards as a result of their dependence on the systems (family and community) that are impacted by those hazards, and the potential for disruption due to developmental vulnerabilities as well as long term impacts over the course of their lifespan.

Policy Recommendation(s):

a. To include and encourage a focus on children and youth in research on energy systems through targeted and ongoing funding priorities.

2. *An emerging body of literature describes a range of negative health impacts of energy activities on children and youth.* Those studies that have begun to investigate the health effects of energy emissions and extraction on developing fetuses, children and youth have revealed that there are health, social, and economic issues related to environmental contamination and or degradation associated with energy extraction and production. This includes direct health impacts related to spills and leaks, dust, noise, toxic waste management, emissions and other environmental impacts (air, water, soil) associated with ongoing operations and the closure of facilities and management of clean up. It also includes indirect impacts related to increased vehicle traffic around and near sites causing greater risk of accidents and also contributing to increased air pollution, and the social and economic impacts of boom-bust economies associated with energy resource extraction industries on families and communities.

Policy Recommendation(s):

a. Health indicators (physical, mental, and population health) and health impact assessments should be incorporated into environmental impact assessments and the ongoing monitoring and evaluation of proposed energy projects.
b. These indicators and assessments should address both short/acute impacts and long-term, cumulative impacts.
c. Accountability measures should be incorporated into such assessments and evaluation processes to support actions to mitigate and prevent adverse consequences of energy resource activities for children, youth, families and their communities.

d. In addition, energy resource development, urban planning, technological innovation, and policies should incorporate a socio-ecological lens that includes and foregrounds children, youth and their families highlighting both potential vulnerabilities and opportunities for empowerment and engagement in decision-making processes.

3. *Psychosocial and cultural outcomes should be considered.* Although relatively few studies have investigated the psychosocial implications of energy resource activities, some studies have established a connection between air pollution and educational and behavioural and social outcomes for youth and children. Further outcomes of relevance include the impact of these activities on access to lands and livelihoods, heightened in- and out-migration, potential increase in tensions, conflict and unrest and other activities (e.g., fishing, hunting, food production, cultural activities) especially in First Nations communities proximal to these resource activities.

Policy Recommendation(s):

a. Integrate and monitor HVAC systems and water quality systems in schools, residential buildings, and other public spaces in which children and youth congregate in areas where exposure to emissions is a risk.

b. Incorporate social impact indicators into environmental impact assessments and the ongoing monitoring and evaluation of proposed energy projects.

c. Develop culturally relevant social impact assessment tools that address concerns specific to First Nations, Metis and Inuit Communities.

4. *The effects of renewable energy extraction and production on children and youth are largely unknown.* This review has further revealed that relatively few studies and consultative practices incorporate a child- and youth-centric approach to understanding and implementing the transition to low- or no-carbon energy systems. The biopsychosocial effects of wind, solar, hydro, and other renewables on young people need to be examined.

Policy Recommendation(s):

a. Prioritize a focus on children and youth in research through funding initiatives and expectations.

b. Adopt a child and youth-centred theory of change in consultation, decision making processes and policy development as governments and industry consider and move forward in this transition.

c. Involve youth as key stakeholders in the proposal, development, and operations of new and existing renewable projects.

5. Youth have great potential for agency in response to energy resource activities. Youth are not only vulnerable to the effects of energy resource activities, but they also desire, and have the capacity and capabilities to be involved in decisions related to the energy resource activities and policies. They are motivated to take action to mitigate and/or prevent those effects and to shape current and future policy and practice in relationship to energy resource activities and climate change.

Policy Recommendation(s):

a. Meaningfully engage youth in the design and implementation of community-based research efforts aimed at capturing youth voices and perspectives related to the impacts of energy activities on children and youth.

b. Support the meaningful participation and contributions of youth in consultation processes at the local, regional, provincial/territorial and national levels, and directly involve them in shaping and influencing policy development and implementation processes.

Executive Summary

Although it is extensive, the knowledge about the biological and psychosocial (biopsychosocial) effects of energy resource activities (including construction, operation, spills, waste management, transportation) and climate change is diffuse, and characterised by a multitude of disciplinary and practice arenas. Fragmentation is particularly evident in the research about the impact of energy resource activities on children and youth, their families, and communities. An overview of this literature reveals that young people are directly and indirectly affected by the social, economic, and environmental impacts related to energy resource activities across energy systems (e.g., oil and gas, hydro-electric, nuclear); yet they are typically excluded from contributing to the planning and policy dialogue around the management of these systems or the anticipated transition to a zero or low carbon future. As such, this omission falls short of the principles and rights inherent in the United Nations Guiding Principles on Business and Human Rights or the Convention on the Rights of the Child and the expectations that children have the right to participate in decisions and matters affecting them. Further, this omission fails to acknowledge the growing awareness/conception of children and youth as active change agents in their lives and those of their community and society, and their role in influencing individual and community resilience in the context of climate change. It also signals a rift between current research, policies, and practices, and an "Imagined Future" for Canada.

This review addresses this disconnect by: capturing, collating and summarising the evidence about the biopsychosocial and economic impacts of energy resource activities on children and youth, in the context of environmental change; describing

young people's engagement in climate change mitigation; and recommending future research and policy directions. A systematic search of the interdisciplinary and international literature was screened for relevance, and complemented with a purposeful search to extend the breadth and depth of the final collection of articles. These were then synthesised according to the biological, psychosocial, and economic impacts of emissions and energy resource activities on children and youth, their families, and communities.

Much of the literature focuses on the direct health or biological impacts of emissions on young people. Emissions or *air pollution* originate from industrial and household energy production sources and processes in the form of gases (ozone), particle matter (smoke), and traffic-exhaust fumes, contaminated with toxic chemicals. Because of their developmental immaturity, and receptivity to exposure through inhalation, ingestion and/or dermal (skin) contact, children are at high risk of significant biological health effects from indoor and outdoor air pollutants. While respiratory conditions, such as asthma, are the most commonly reported emission related health impacts in children and youth, the type, extent, and severity of exposure is subject to environmental conditions–location (proximity to industrial sites), source of industry (petrochemicals, coal), traffic patterns (urban/rural), weather conditions (smog), and seasonal variations; as well as the composition of the pollutant. For instance, the impact of nuclear emissions depends on the time (pre and/or postnatal) and degree (short and/or long-term) of children's exposure to radiation. Some studies suggest that the co-exposure to different emissions, and the synergistic interactions of chemical toxins through direct exposure (e.g., ingestion of contaminated soil or water) may also be associated with higher rates of multiple forms of cancer, and other acute and/or longer-term health effects, and may also

result in substantive biodevelopmental and neurodevelopment effects, including delays to cognitive function, motor performance, and social behaviour in young people. From this perspective, it is surprising that the research about the corresponding psychosocial and economic impacts for children, families and communities is very limited.

This orientation is reversed in the literature about the effects of energy resource extraction (mining, drilling, nonconventional natural gas extraction - fracking). Literature on extraction activities focuses on the large-scale operational removal of solids (metals, minerals), liquids (oil) and/or gases (natural gas), primarily in rural and remote locations. Although youth employed in these industries are exposed to a range of biophysical and occupational hazards, including contaminated dust, excessive noise and vibrations, and work-site accidents, there are few accounts in the literature of how these activities impact the biological and mental health of youth. Oil and gas and other energy resource activity is also associated with social and economic development resulting in such things as purpose-built towns, long distance commuting, high incomes, and concomitant psychosocial and economic implications. For youth living in and near energy resource activities, health implications can include increases in risky and delinquent behaviours, mental health problems (depression) and other concerns related to disrupted or unpredictable family routines and relationships (*see saw* solo to co-parenting arrangements, domestic abuse); and by the impact on families and communities of *boom and/or bust* resource-dependent economies. Contemporary reports on nonconventional natural gas extraction (i.e., fracking) and oil sands activities provide community-level perceptions of biological risks, and the cultural, and psychosocial adjuncts to the

resource-curse paradox, where resource-rich communities experience low incomes and social wellbeing.

Overall, this review demonstrates that children and youth exhibit a wide range of biopyschosocial and economic effects related to their exposure to energy resource activities, especially those related to carbon-intensive energy emissions and extractions (i.e., oil, gas, fracking). This review further demonstrates a general lack of focus in the literature on these direct and indirect impacts of these activities on children and youth. Where children youth are the focus of study, they are most often framed one dimensionally as a vulnerable population in need of protection, rather than as citizens with rights and potential agents of change in their communities. However, an emergent literature describing youth engagement and activism in response to energy activities, also signals that youth stand poised as a significant sustainability and resilience multiplier.

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Context

The future of energy resource activities, especially carbon-intensive options such as natural gas and oil, present a major challenge for international economic and social sustainability. There is a global recognition of the role that the extraction and use of high-carbon energy resources has in contributing to carbon emissions and climate change. As a result, many countries–including Canada–are working to transform energy systems (development, extraction, production, consumption) and the complex of associated social and economic systems. This transition to forms of low- or no-carbon energy alternatives (wind, solar, tide) and low-carbon goods and services based economies are a priority for industry stakeholders as well as the Canadian government's sustainable development goals (National Round Table on the Environment and the Economy NRT, 2012). Such a transformation will require a paradigm shift in the sourcing, extraction, processing, and delivery of energy resources in ways that minimizes the negative impacts on humans and their communities, while also supporting sustainable economic development and individual and collective resilience.

Children (aged from 0 and 14 years) and youth (aged from 15 to 24 years) emerge as key population groups that are impacted by energy resource activities and global energy choices (United Nations Children's Fund UNICEF, 2013). Today's children and youth will live and work through the challenges of energy systems transitions and climate change. In some regions of Canada (and globally) children and youth are already contending with the direct impacts of natural resource extraction on their functioning (Goldenberg, Shoveller, Koehoorn & Ostry, 2010) and the functioning of their communities and physical environments (US Environment Protection Agency EPA,

2015). Children and youth are more vulnerable to environmental toxins and hazards than adults because of metabolic, developmental and behaviour factors (American Academy of Pediatrics, 2011). They are also at risk because of the implications of the social, economic and other impacts of energy resource activities on the well being of their families and communities. Despite this, children and youth are noticeably absent from the social science literature on natural resources and energy systems research, and are typically excluded from impact assessments and national development plans and policies (Assad, Barsoum, Cupito & Egel, 2009; Goldenberg et al., 2010).

Young people are potentially powerful actors in developing and implementing the energy transition in Canada and internationally. It is important, therefore, not only to understand the social, economic and health dimensions of energy systems for children and youth, but also their potential roles as energy resource innovators and contributors to the economic sustainability and whole-of-community resilience of their communities and to society.

Implications

The Imagining Canada's Future Initiative highlights: the need for sustainable resilient communities; and creativity, innovation and prosperity as two of the four enduring issues that are central to all six future challenge areas. To address these two central issues, the Resilience by Design (RbD) Research Lab at Royal Roads University (RRU) and the Resilience Research Centre (RRC) at Dalhousie University collaborated to review children and youth's resilience in the context of energy resource production, climate change, and the need to transition to low-carbon goods and services. This goal

was addressed via a systematic interdisciplinary search, review, and synthesis of extant social and behavioural science research to describe the current state of knowledge, identify critical gaps, and highlight effective policies and practices related to: the socio-economic and health dimensions of energy resource systems[1] and the energy transition; the biological, psychological, and social (biopsychosocial) impacts of energy systems on children and youth and their vulnerability, resilience and adaptive capacity; and effective policy and practices of energy resource extraction and production that foster resilience in communities, children, and youth[2].

The review also provides a window into the nascent literature about children and youth as active agents of change in the context of the energy transition and climate change. It outlines strategies for engaging and empowering children and youth as leaders, innovators, and change makers in Canadian and global contexts, and recommends future directions for research focused on children and youth as actively engaged citizens and potential leaders in the transition to a low carbon goods and services economy.

Approach

A critical interpretative synthesis of the literature (Dixon-Woods et al., 2006) was the overarching methodological approach adopted for the review. This approach provides a flexible and responsive framework to accommodate the challenges embedded in this investigation (Table 1):

[1] Energy systems describe the process of energy resource exploration, extraction, production/processing, transmission/transportation and final use from: hydrocarbons (oil, natural gas, and coal); nuclear; and; renewables (water/hydroelectric, solar, wind).
[2] Children and youth are defined as young people under the age of 30 years.

Table 1: Synopsis of critical interpretative synthesis

Elements	Critical Interpretative Synthesis
Research question	• evolves throughout the review process • changes are transparent
Literature search	• exhaustive search strategy • purposive sampling outside the original search parameters is permitted. Additional articles are selected to provide further insights • inclusion and exclusion criteria are iteratively refined to reflect the evolving question
Rating of articles	• articles are rated for relevance (rather than quality)
Synthesis	• data is extracted from the search findings via an analytical framework. The ensuing constructs are iteratively revised and reapplied to the included papers to ensure that the constructs are grounded in the data

(modified from Wilson et al., 2014)

The search strategy was also informed by Wilson and colleagues' (2014) adaptive protocol.

Consequently, an iterative, phased approach was implemented to: firstly, systematically isolate and collate the international and interdisciplinary research on the impacts of energy resource activities on children and youth; then, extend this review to related and grey literature focused on the psychosocial and economic implications of energy resource activities on young people, families, and communities; and finally,

consolidate and integrate the findings into a comprehensive biopsychosocial synthesis that provides a contemporary social-ecological perspective on the impacts of energy resource activities on children and youth. The review concludes with a synopsis of the nascent literature young people as active change agents in the context of energy systems and global climate change. Gaps are highlighted when they occur in the literature.

At this point, it is important to note that the review foregrounds the deleterious effects of energy resource activities on children and youth. However, the concomitant benefits of energy production and availability on infrastructure, livelihoods, and lifestyles are also acknowledged (Banks, 2009; Mactaggart, McDermott, Tynan & Gericke, 2016). Analogously, while the systemic impacts are treated as separate entities to expedite the review process and underscore the findings, this is a pragmatic demarcation only. In reality, the effects overlap and/or intersect.

Search Strategy

The search strategy encompassed three interconnected phases: phase one involved a systematic literature search informed by study-specific data screening and extraction protocols; phase two consisted of purposive sampling to broaden the search to include additional relevant information; and phase three integrated these findings into an analytical framework (Wilson et al., 2014). As each phase is associated with a different set of limitations, these are discussed *in situ*, rather than as a separate section following the results.

Phase one: Systematic literature search and study-specific data screening and extraction protocols.

Since the research "question…drew on literature that was not well developed or focused" (Wilson et al., 2014, p. 3), the multi-disciplinary research team held a preliminary planning session to derive potential search terms for each key construct– energy systems, natural resource production, climate change, children and youth, impacts, and resilience. These terms were then piloted through an exploratory (non-systematic) search using the Google Scholar database. The resultant palette of articles reflected the complex interdependencies between the constructs, and demonstrated inconsistencies in analytical dimensions (health, social, economic, ecological, cultural/spiritual), operational impact (direct/indirect, gene/environment, upstream/downstream, mediating and/or moderating effects), temporalities (short-term/long range), and spatialities (global, regional, local). As a result, the team developed a matrix to cross-reference energy systems against projected types of impacts. In addition to constraining these wide variations, the matrix also facilitated a re-conceptualisation and refinement of the search terms. For example, the boolean operator *not* isolated petrochemical oil from fish, soya, and palm oils, and eliminated articles about oil-related food production rather then energy production, and *not nuclear medicine* increased the relevance of nuclear energy system searches. Further inclusion and exclusion filters were applied to increase salience, including language (English), date (between 2005 and 2016/current) fields, and *peer reviewed*, *scholarly*, and *full text* conditions. Appendix one provides a comprehensive list of search criteria and terms.

Moreover, databases that were incapable of managing multiple coterminous search fields, such as Google Scholar, and JSTOR (limited to eight search terms per field)

were rejected. The dual requirements of this systematic search, namely simultaneous search functionality and the salience of constituent databases, were ultimately met by the EBSCO and PROQUEST databases. Identical search criteria were used in each database, but yielded different results according to the sub-database population. Refer to Appendix two for a list of the sub-databases used in the EBSCO search.

A total of 18,000 articles were identified on the initial search. This number was subsequently delimited through more restrictive conditions, such as incorporating children and youth in the title field. The final systematic search yielded 924 articles, and after screening the titles and abstracts for relevance, the remaining 211 (Table two) were reviewed in terms of the impacts of specific energy system activities on children and youth.

Table 2: The number of articles per database for each energy system.

Energy system	Articles that passed final screening from each database			
		EBSCO database	PROQUEST database	Total articles
Petrochemicals/ Hydrocarbons		1	0	1
	Oil	42	10	52
	Coal	21	5	26
	Gas	48	5	53
	Total			132
Nuclear		47	5	52
Renewable		12	2	14
	Water (hydroelectric)	9	0	9
	Wind	2	2	4
	Solar	0	0	0
	Total			27
Totals		182	29	211

Overview of Results

Table two indicates that the majority of these articles related to the oil and gas and nuclear energy industries, with significantly fewer articles about renewable energy systems. Most articles centred on the health effects of energy systems on children and

youth, rather than psychosocial and/or economic outcomes, and 30 articles discussed young people's education, awareness, and perceptions of the risks and impacts associated with different energy systems. Surprisingly, few articles focused on Canada, and none pertained to the major Canadian oil sands projects.

Some caveats apply at this juncture. Only two databases were used for the search and possibly restricted and/or skewed the results. The search terms were also combined and administered as a unit, rather than separating them into logical packets and using repeated searches. And as previously observed by Assad and colleagues (2009) and Goldenberg and colleagues (2010), children and youth are noticeably missing from the social science literature on natural resources and energy production, especially with regard to psychological, social, and economic impacts. The absence of substantive Canadian data is also perturbing, especially with respect to Canada's history of extensive natural resource development. These deficits were addressed with an additional purposeful review (Wilson et al., 2014).

Phase two: Multifaceted purposive sampling review.

A range of resources and sources was accessed for this purposive literature review (Table three). They were tailored to populate the gaps identified above, in particular, the psychosocial and economic impacts of energy resource systems on children and youth, and the Canadian context.

Table 3: Purposive sampling approach

Resource	Search targets
Complementary literature reviews (annual reviews, systematic reviews, special editions of journals)	Reference snowballing Key articles Author citations/publication lists
Non-systematic, targeted literature searches (Google Scholar, popular media)	Grey literature Key words

In addition to locating specific information about the differential impacts of energy system activities on children and youth, this review confirmed and supplemented the previous findings. It also captured contemporary, up-to-date information about the natural resource sector in industrialised countries, and the Canadian response to climate change. However, a further caution applies here; even though the literature searches were extensive and comprehensive, the global energy and environmental arenas are evolving very rapidly, and this review portrays a time-limited snapshot only.

Again, following Wilson and colleagues' (2014) guidance, this additional literature was integrated with the earlier results to develop an analytical framework. As such, the key constructs were constantly and iteratively revised in relation to the included papers, thereby ensuring that they were grounded in the data. They were also categorised to represent the effects of natural resource production on young people, thus broadly mirroring the economic and gene-environment contributions to biopsychosocial wellbeing. The final social-ecological framework was re/ordered to reflect an individual,

family, and then community perspective, to present a strong evidence base and rationale for children and youth as change agents (Table four).

Table 4: Social-ecological framework cross-referenced to results (according to number)

IMPACT			
System	1. Emissions		
	Effects		
	1.1 Individual	1.2 Family	1.3 Community
Biological			
Psychosocial			
Economic			
	2. Extraction		
	Effects		
	2.1 Individual	2.2 Family	2.3 Community
Biological			
Psychosocial			
Economic			

Because of quantity and heterogeneity of the included articles, a table summarising the key characteristics of each study was not realistic. A narrative synthesis configured on social-ecological framework was implemented as a more accessible alternative.

Results

1. Emissions

In this review, emissions are defined as outdoor and indoor air toxins originating from both industrial and household energy production sources and processes. Popularly termed *air pollution*, emissions are categorised as criteria pollutants by the USA Environmental Protection Agency EPA (2003), namely, gases (ozone, carbon monoxide, sulphur dioxide, nitrogen dioxide), particulate matter (carbon/smoke), and lead (traffic-related exhaust). An alternative taxonomy relates to the size of particulates: the smaller respirable particulate matter ($PM_{2.5}$ and PM_{10})[3] (Trasande & Thurston, 2005) and bioengineered ultrafine particles (Biskos & Schmidt-Ott, 2012; Heinzerling, Hsu & Yip, 2016) are most applicable to this review. Other classifications differentiate between indoor (household) and outdoor air pollution (Smith et al., 2013), or by geographical location–city, country, and/or region, as in Latin American (Laborde et al., 2015).

Young people's vulnerability to the direct and indirect effects of these emissions is increasingly well documented (Burtscher & Schüpp, 2012; Schüpp & Sly, 2012; Trasande & Thurston, 2005; Trasande et al., 2015). Because of their immature and developing biological, psychological, and social systems (D'Andrea & Reddy, 2016), children and youth are more susceptible to these environmental (exogenous) insults (Currie, Graff Zivin, Mullins & Neidell, 2014). There is also a nascent empirical evidence base about the endogenous impacts of this exposure on later-life outcomes (Currie et al., 2014; Miller & Marty, 2010).

[3] $PM_{2.5}$ is less than 2.5μm in aerodynamic diameter and PM_{10} is less than 10 μm in aerodynamic diameter.

A synthesis of the effects of emissions on children and youth are nested within a social-ecological framework, is provided as follows:

1.1 Individual effects.

1.1.1 Biological.

Air pollution exerts an adverse impact on health in general (Health and Places Initiative, 2014), and for children and youth in particular (Pelallo-Martínez, Batres-Esquivel, Carrizales-Yáñez, & Díaz-Barriga, 2014). Compared with adults, young people demonstrate greater exposure to these pollutants (Bateson & Schwartz, 2007; Sánchez-Guerra et al., 2012; Smith et al., 2013; Tzivizian, 2011), and higher per-minute ventilation rates and body-mass exposure ratios (Schüpp & Sly, 2012).

In terms of biological effects, emission exposure in children is largely associated respiratory problems (D'Amato, Cecchi, D'Amato & Liccardi, 2010): early onset respiratory symptoms (Rosa et al., 2011), and both upper and lower respiratory tract conditions, such as asthma (Bateson & Schwartz, 2007; Gale et al., 2012; Gauderman et al., 2015: Tzivian, 2011), and bronchitis (Bateson & Schwartz, 2007).

Moreover, Rovira and colleagues (2014) found that these respiratory health effects are dynamically altered by the exposure characteristics of the industrial site's location, such as meteorological factors (wind, sun, rain), industrial processes and production technology; ancillary sources of pollution (construction, traffic); air quality regulations (control and monitoring); and seasons (Altuğ et al., 2013). Complementary studies (Laborde et al., 2015; Rusconi et al., 2011; Smargiassi et al., 2014; White et al., 2009; Wichmann et al., 2008) confirmed that living within a petroleum refinery area

exerts a detrimental and/or aggravating impact on children's respiratory systems. Similarly, residence near a large industrial site (petrochemical, fertiliser and cement factories; oil refineries; a natural gas company, and a power generating station) was associated with significantly higher proportion of congenital cardiovascular defects (Abood & Hassan, 2014).

Petrochemical production also creates a pool of toxic gases (carbon monoxide, nitric oxides, sulphur dioxide) and chemicals, in particular, volatile organic carbons (VOC) such as benzene, and polycyclic aromatic hydrocarbons (PAH)'s. Each of these substances is independently hazardous to health, but when they are mixed as an *emissions cocktail*, the impact of these complex compounds is a variable unknown (Pelallo-Martínez et al., 2014). For example, after a flaring incident at a petroleum refinery, children exposed to benzene demonstrated a greater chance of developing haematological and hepatic impairments (D'Andrea & Reddy, 2016), leukaemia (Whitworth, Symanski & Coker, 2008), and delayed psychomotor and cognitive skills (Lertxundi et al., 2015). Furthermore, PAH's result from the incomplete combustion of fossil fuel sources (wood, oil, coal) and constitute a melange of many chemically related, organic compounds (Orris & Burt, 2013), with substantial bio-developmental implications for young people. These include: genotoxic effects–alterations in DNA (Burt, Orris and Buchanan, 2013): tetragenic effects–intrauterine foetal growth restriction (Polanska, Hanke, Sobala, Brzeznicki & Ligocka, 2010); neonatal effects–adverse birth outcomes (low birth weight, premature delivery) (Smith et al., 2103); respiratory effects–reduced lung function (Roy et al., 2012; Padula et al., 2015; Götschi, Heinrich, Sunyer & Künzli, 2008); and neurodevelopmental effects–delays in cognitive function, motor performance, and social

behaviour (Perera et al., 2006, 2008, 2009, 2012). The seriousness of PAH exposure depends (in part) on the length, amount, and route of exposure (Han, Zhang, Niu, Han & Bai, 2014). Since PAH's are transmitted via gaseous and/or particulate matter with concomitant vectors of exposure (inhalation, ingestion, or dermal contact), co-exposure is also a major contributor to the health profiles of young people. Cooking and heating homes with solid fuel (coal and wood) (Rehfuess, Mehta & Pruss-Ustun, 2006) precipitates synergic reactions between PAH's and environmental carbon (Kim, Kam & Lee, 2014). These interactions contribute to indoor air pollution, especially if the space is unventilated (Murray et al., 2012; Roy et al., 2012).

Household air pollution increases both mortality and morbidity in children and youth (Masera, Bailis, Drigo, Ghilardi & Ruiz-Mercado, 2015), where life-limiting diseases (Lui et al, 2015) include tuberculosis (Smith et al., 2103), pneumonia (Baker et al., 2006; Dherani et al., 2008; Murray et al., 2012) and cancer (Han et al., 2014); and life-restricting impacts encompass neonatal and cognitive developmental impairments (Smith et al., 2103).

Even though "household air pollution is the leading environmental risk in the global burden of disease" (Masera et al., 2015, p. 123), the quality of the ambient (outside) air is critical for children and youth's biodevelopment (Sun, Hong & Wold, 2010) as well. Coal fired power generating industries emit composite emissions consisting of metals (arsenic, lead, mercury, cadmium), gases (oxides of nitrogen–ozone/*smog*, nitrous oxide, nitrogen dioxide), and PAH's (Burt et al., 2013; Tang et al., 2008). Exposure to the PAH's, heavy metals (Yapici et al, 2006), and carbon particulates in coal emissions severely impacted children and adolescents' cardiopulmonary and

reproductive health (Burt et al., 2013), and cognitive, motor, language, and social growth (Burt et al., 2013; Suglia, Gryparis, Wright, Schwartz & Wright, 2007; Tang et al 2008).

This indoor/outdoor couplet is further complicated by the differences in emissions between urban and rural areas (Health and Places Initiative, 2014; Wang & Zhang, 2006), traffic patterns (Jyethi, Khillare & Sarkar, 2014), and seasons (Altuğ et al., 2013)– in essence, children and youth are exposed to multiple types and levels of emissions that vary across time and space.

Alternatively, nuclear emissions can be (mostly) isolated to a specific incident (an explosion or leak), leading to a significant biological impact on young people, especially following a nuclear accident. Children and youth are at most risk for developing health effects from nuclear radiation (Tsubokura et al., 2015), specifically a greater incidence of thyroid cancer (Fushiki, 2013), non-Hodgkin lymphoma, and leukaemia (Wakeford, 2014). According to Fushiki (2013), the type or severity of these effects is also influenced by the amount and duration of radiation exposure. Here, the literature is inconsistent, particularly with respect to a *safe* exposure dose (Fushiki, 2013), and a *safe* exposure distance (Hung, Horng, Yen, Lee & Lee, 2015). At present, there is no definitive evidence of a carcinogenic effect for acute radiation at low dose-rates and doses, but Fushiki (2013) advises prudence because of children's greater sensitivity to radiation-related risks, and their longer life expectancy to express the health effects of exposure.

And while research by Kaatsch, Spix, Schulze-Rath, Schmeidel and Blettner (2008) and Sermage-Faure and colleagues (2012) determined that children living in close proximity (five km) to a nuclear power plant exhibited a higher risk of leukaemia, Bithell and colleagues (2013) refuted these results with UK data. Overall, it is unclear if the

elevated child cancer rates that were detected in Germany (Kaatsch et al., 2008) and France (Sermage-Faure et al., 2012) are due to increased exposure, advancements in detection (Wakeford, 2014), or the underestimation of *in utero* sensitivity to nuclear radioactivity (Fairlie, 2009).

However, the research about foetal radiation risk is now more decisive. Although the specific impact of radiation on the developing foetus depends on the stage of pregnancy and absorbed dose, the early foetal prenatal periods demonstrate most sensitivity to nuclear exposure (Fushiki, 2013). Maternal exposure to radiation at these critical times has profound implications for the development of the foetal central nervous system, leading to childhood microcephaly and seizures (Fushiki, 2013), severe neurophysiological dysfunction (Heiervang, Mednick, Sundet & Rund, 2010), and compromised cognitive ability (Almond, Edlund & Palme, 2009).

1.1.2 Psychosocial.

Despite the major health effects of young people's exposure to industrial and household emissions, the coterminous literature addressing psychosocial impacts is limited. Much of this scholarship centres on the educational implications of children's diminished cognitive performance as a consequence of exposure to air pollution (Bharadwaj, Graff Zivin, Gibson & Neilson, 2014; Lavy, Ebenstein & Roth, 2014), or nuclear radiation (Almond et al., 2009; Black, Bütikofer, Devereux & Salvanes, 2013). For instance, a paper by Reyes (2014) focused on the relationship between exposure to lead in early childhood, and subsequent behavioural outcomes. Her results showed that moderate levels of lead exposure trigger an age-specific cascade of antisocial and risky

behaviours–younger children *acting out*, teen-age aggression, and young adult criminal activity (Grönqvist, Nilsson & Robling, 2014).

By contrast, two contemporaneous studies (Bromet et al., 2011; Heiervang et al., 2010) addressed the psychological wellbeing of children and youth exposed to radiation from Chernobyl. In Heiervang and colleagues' (2010) study of pre-natal exposure, the children's psychological health was protected by their mother's physical and psychological *distance* from the disaster. Bromet and colleagues (2011) investigated the risk perceptions and mental health impacts of young people who experienced first-hand (post-natal) exposure to the nuclear fallout. They failed to establish strong connections between the adolescents' evacuee status, the presence of depression and anxiety disorders, and perceptions of risk, and concluded that these youth escaped the "psychological burden of Chernobyl" (p. 401).

Notwithstanding the considerable methodological limitations noted in Bromet and colleagues' (2011) research, "the topic of Chernobyl was of little interest to the adolescents" (p. 400). This proposition dovetails with USA students' pervasive belief that "global warming and climate change will [not] have a major impact on people or society. There is no perceived consequence in the students' life." (Shepardson, Niyogo, Choi & Charusombat, 2011, p. 495) (The findings from Shepardson and colleagues' (2011) exploration of American students' conceptions of global warming and climate change are reintroduced in later sections.)

1.1.3 Economic.

To date, there are very few studies about the economic impact of industrial and household emissions on children and youth. This omission can be attributed to multiple

methodological and analytical challenges: the heterogeneity of emissions, exposure, and children/youth; and evolving and varying circumstances (among others) (Smith et al., 2013). Until the development of new biomarkers (Fushiki, 2013), school achievement is often used as a proxy for future income and employment (Currie et al., 2014; Grönqvist et al., 2014), as in Bharadwaj and colleagues' (2014) extrapolation of foetal carbon monoxide exposure to school performance to lifetime earnings. Similar projections relate prenatal nuclear exposure to educational accomplishment and subsequent income (Black et al., 2013), and lead exposure in early childhood to later scholastic ability and labour market outcomes (Nilsson, 2009). Each study represents a comparable scenario; namely, exposure to toxic emissions in early life leads to significant economic penalties in later life.

1.2 Family.

1.2.1 Biological.

With respect to the centrality of the family unit for children and youth, it is perhaps surprising that the literature addressing the biophysical effects of energy-related emissions on families is largely subsumed under the corresponding research about the individual. For instance, indoor air pollution affects all members of a household, but most analyses are directed towards individual level impacts. And as observed previously, mothers are referenced primarily in the context of their prenatal susceptibility to emission toxicity, and to a lesser extent, their perceptions of the health and wellbeing implications of this exposure–again in relation to their children. Fathers, siblings, and grandparents are notably absent from the majority of this literature.

However, a recent study by Black and colleagues (2013) rectifies this deficit. The authors examined the long-range impact of prenatal radiation exposure on individuals, siblings, and the children of parents affected *in utero* (second generation effects). In addition to other outcomes, they determined that "a large proportion of the adverse cognitive effects of radiation exposure is passed on from father to sons." (p. 27) Although these findings apply to sons rather than daughters because of the constraints of the sample, they provide robust evidence for the intergenerational transmission of the cognitive impact of exposure to nuclear emissions.

1.2.2 Psychosocial.

Research into the psychosocial effects of children and youth's family exposure to noxious emissions tends to be strikingly under-represented, and scattered across different literatures (Bolte, Tambulini & Kohlhuber, 2009). It is broadly characterised in two ways: isolated snapshots of individual-level psychological wellbeing (Heiervang et al., 2011), without accounting for wider social relationships; or societal-level social indicators (Bolte et al., 2009; Hoffman et al., 2009), without accounting for rich personal contextualisations. While emissions, children, and youth are common to the psychological and social perspectives cited by these authors, a family-centric focus is missing.

1.2.3 Economic.

In general, the literature suggests that families with a lower socioeconomic status experience more severe effects from air pollution (Bolt et al., 2009; Hoffmann, 2009), where economic impacts are operationalised through socioeconomic indicators such as educational attainment, poverty, unemployment, and earnings (Bell &

Ebisu, 2012). As such, these interdependencies are underpinned with normative assumptions: equivalency–population-level measures are representative of the complex composition of the modern family; and linearity–the relationship between socioeconomic status and health outcomes is (often) portrayed as causal and unidirectional, rather than dynamically bi-directional or cyclic (Gee & Payne-Sturgess, 2004).

1.3 Community.

1.3.1 Biological.

Along similar lines, the perception that "disadvantaged communities face greater likelihood of exposure to ambient hazards." (Gee & Payne-Sturgess, 2004, p. 1645) is frequently extrapolated to the adverse health effects of coal-ash landfills or ponds (Zierold & Sears, 2014), industrial sites, and power-generating plants (Brender, Maantay & Chakraborty, 2011). In Canadian Indigenous communities, such as Fort Chipewyan in Northern Alberta, proximity to oil production has been linked to increased rates of cholangiocarcinoma over the past 30 years (e.g., Tenenbaum, 2009), although these studies have not specifically focused on youth.

This "exposure-disease paradigm" (Gee & Payne-Sturgess, 2004, p. 1646) was tested in communities experiencing long-term (20 year) impacts from the Chernobyl nuclear incident (McMahon et al., 2014; Montoro et al., 2013). Although children and youth were at risk of low-level radiation exposure by ingesting local food grown on contaminated soil, neither study found definitive evidence of substantive damage to their biological systems. And while the result supports Brender and colleagues' (2011) advice that "proximity does not necessarily equate to individual-level exposure" (p. S50), it also

signals the challenges involved in shifting between community processes and individual mechanisms (Gee & Payne-Sturgess, 2004).

1.3.2 Psychosocial.

For Gee and Payne-Sturgess (2004), *community stress* captures the psychosocial impacts of community-level exposure to emissions on children and youth:

> When community stressors and pollution sources outweigh neighbourhood resources, levels of community stress manifest or increase. Community stress is a state of ecological vulnerability that may translate into individual stressors, which in turn may lead to individual stress. Individual stress may then make individuals more vulnerable to illness when they are exposed to environmental hazards…compromises in individual and community health may further weaken community resources, leading to a vicious cycle. (p. 1646)

These multi-level interactions are then expressed as a stress-exposure-disease model (Gee & Payne-Sturgess, 2004).

1.3.3 Economic.

Finally, Brender and colleagues (2011) trace the economic impact of community exposure to energy-related emissions to *disease clusters*. According to public perception in the USA, communities that are associated with toxic waste, air pollution, and/or contaminated water are also linked to negative health effects, and by default, the notion of safe/*good* and/or unsafe/*bad* neighbourhoods.

2. Extraction

For this review, energy resource industry extraction encompasses the production and processes involved in extracting solids (metals and minerals such as coal and ores), liquids (crude petroleum), and gases (natural gas). In this context, extraction represents both the operational removal of the product (quarrying, drilling, milling–crushing, screening, washing or flotation), as well as ancillary developmental, support, and maintenance systems, such as site preparation (construction of dams for hydroelectric power) and infrastructure (creating resource towns and transportation hubs) (North American Classification System, 2012).

The majority of the energy resource extraction industries are large-scale operations, situated in relatively remote locations, and popularly characterised as *boom and bust* economies. While much of the research into this sector is oriented towards the environment, and public and occupational health effects (Goldenberg et al., 2010), there is an evolving literature about the concomitant psychological, social, and economic impacts at individual, family and community levels.

Additional caveats apply to this section: first, the parameters of study disallowed the inclusion of the extensive literature about energy resource extraction in developing countries; and second, because of the extensive literature about energy resources in Australia, it is (unintentionally) skewed towards an Australian perspective. However, as for Hajkowicz, Heyenga and Moffat (2011), this literature is rich, relevant, and representative of the sector.

Accordingly, this section synthesises the biopsychosocial and economic impacts of resource extraction, with a specific focus on children and youth.

2.1 Individual effects.

2.1.1 Biological.

A partial list of the biophysical risks associated with energy resource extraction processes coalesce around exposure to: fumes, smoke, dust, soil, and water containing particulate matter contaminated with asbestos, arsenic, cadmium, mercury, silica; and extreme environmental conditions (excessive noise, vibration, heat, cold). Work-site accidents (explosions, structural collapse), hazards (poor safety standards), and irregular work patterns (shift-work, fatigue) also impact physical and mental health outcomes (Education and Health Standing Committee, 2014; Petkova, Lockie, Rolfe & Ivanova, 2009; Witter et al, 2010). While children are not typically exposed to physical and occupational health risks[4], youth employed in large-scale resource extraction industries are highly vulnerable to these effects. Environmental contamination is also associated with changes in diets particularly in First Nations communities that must shift from a reliance on local, traditional foods to less nutritional and more expensive alternatives (McLachlan, 2014). These changes are associated with poorer health outcomes, disruption of potentially protective cultural and social practices (e.g., trapping, hunting, local food production), and more generally to the well-being of families and by implication, children and youth (ibid)

[4] According to the International Labour Organisation (2016), child-labour practices are still a reality in smaller scale mining and quarrying.

2.1.2 Psychosocial.

The biological impacts of energy resource activities are compounded by the risky (Mactaggart et al., 2016) and maladaptive (Carrington, McIntosh & Scott, 2010) behaviours connected with living in resource towns. Canadian and Australian literature suggested that "a 'masterless underclass' of youth seeking excitement, entertainment and opportunity" (Banks, 2009, p. 49) contributes to the incidence of prostitution and sexually transmitted infections (Goldenberg et al., 2010), pregnancy and abortions (Shandro, Veiga, Shoveller, Scoble & Koehoorn, 2011), addictions to drugs and alcohol (Goldenberg et al., 2010), and violence (Carrington et al., 2010; Gilmore, Liang & Chikritzhs, 2016) in many resource towns.

Furthermore, "Miners and their partners suffered more psychological stress…due to social isolation, especially from relatives; boredom, climate, the transient nature of towns and their atypical populations" (Petkova et al., 2009, p. 213). Young adults also reported a higher rate of affective disorders (depression) compared to older age groups after the closure of mines (Carta et al., 2012). This was related to limited social and employment opportunities (Shandro et al., 2011; Petkova et al., 2009).

2.1.3 Economic.

Employment in the energy resource extraction industries offers skilled and unskilled young people (predominantly men) an opportunity to earn very high incomes (Hoath & Pavez, 2013). This type of work is frequently contractual (time-limited), and based on a *fly in/fly out* (FIFO) model, characterised by episodic long distance commuting; temporary residency; and separation from home, family, and other social support systems (Clifford, 2009; Education and Health Standing Committee, 2014).

Young people's acceptance and/or satisfaction with this lifestyle vary according to individual and relational needs and preferences, the juxtaposition of personal and built environments, and the provision of amenities and services (Sibbel, Kaczmarek & Drake, 2014). For single workers, women (Pirotta, 2009) and men (Torkington, Larkins & Gupta, 2011), a transient lifestyle is an impediment to forming and retaining close relationships. And according to Lozeva and Marinova (2010), mining (*men's*) towns restrict the employment possibilities and life-chances of women and children.

2.2 Family effects.

2.2.1 Biological.

As noted previously, youth working in energy resource extraction are exposed to significant biophysical risks, with a correspondingly variable impact on family wellbeing (Hendryx, 2013). While appreciating that biological and psychosocial health is coterminous, the literature discussing the implications of physical dysfunction for family members is unexpectedly quiescent.

2.2.2 Psychosocial.

On the other hand, the psychosocial effects of the extraction industries on family relations are increasingly well documented (Hajkowicz et al., 2011; Meredith, Rush & Robinson, 2014; Petkova et al., 2009), as in Sibbel's (2010) comprehensive analysis of the positive and negative spill-over aspects of the work/family dynamic.

There is a significant overlap between the demographic profile of the FIFO workforce, and young men who represent the highest risk of depression and suicide in Australia (Education and Health Standing Committee, 2014). Amplified by a hyper-

masculine *blokey* culture (Carrington et al., 2010), mental health problems tend to be stigmatised and hidden in resource-dependent communities (Education and Health Standing Committee, 2014; Torkington et al., 2011). For example, unresolved individual, family, and/or work-related psychological stress may lead to depression and anxiety, and/or suicide, with a concomitant effect on family wellbeing (Education and Health Standing Committee, 2014; Sibbel, 2010, p. 37).

Each FIFO model[5] has a comparable impact on the family at home: social isolation and loneliness (Hoath, Haslam & McKensie, 2013); disruption and tension from the *see-saw* transition between solo to co-parenting (Meredith et al., 2014); and a greater risk of domestic abuse and family violence (Shandro et al., 2011). Nonetheless, in an adaptable and communicative family (Taylor & Simmonds, 2009), these FIFO arrangements do not appear to significantly affect children's wellbeing (Kaczmarek & Sibbel, 2008). However, since then, a review by Meredith and colleagues (2014) supported Bradbury's (2011) proposition that children are negatively impacted by FIFO conditions, but these effects are mitigated with a "maternal buffer".

2.2.3 Economic.

Financial remuneration is a major incentive for family members working in the energy resource-extraction sector (Misan & Rudnick, 2015; Windel & Rolfe, 2013). In *boom* times, a high salary compensates for the personal and social difficulties inherent in a FIFO work/home model, and enables families to maintain established routines and networks. But "evidence suggests that correspondingly expensive lifestyle choices can become a trap for some families, particularly if the FIFO lifestyle is found to be

[5] Other variations of the FIFO model include drive-in/drive-out (DIDO), bus-in/bus-out (BIBO), and long distance commuting (LDC).

unsuitable and the need to go back to previous income levels is problematic due to financial over-commitment." (Meredith et al., 2014, p. 10) A *bust* economy, with enforced downsizing and/or out-migration due to unemployment and poverty, is equally difficult for families (Tonts, Plummer & Lawrie, 2012).

2.3 Community.

2.3.1 Biological.

There is a large evidence base detailing the occupational and public health impacts of energy resource extraction on a community. Consequently, this section examines the literature underpinning the emergent and highly controversial nonconventional natural gas extraction or fracking industry (Weber, Geigle & Barkdull, 2014) in relation to children and youth. Very simplistically, fracking involves the pressurised (hydraulic) fracturing of shale to release natural gas and oil. Although the *produced water* varies in composition according the geological site and flushing fluid, potential sources of pollution include trace elements (mercury, lead, arsenic) and organic chemicals (VOC's and PAH's) in water, and methane, ozone, and silica in the air (Goldstein et al, 2014).

In a survey about their perception of fracking, some residents of shale-rich communities in the USA listed health risks–consumption and contamination of freshwater, air pollution, noise, and landscape aesthetics, whereas others credited fracking for boosting tax revenues, property values, and public sector resources. Here, public opinion was polarised–fracking was viewed as a public health and environmental issue, or a driver of local economic growth (Auyero, Hernandez & Stitt, 2016). By contrast, corresponding groups of youth in these localities were deeply ambivalent about

the benefits associated with fracking (Burger, Nakata, Liang, Pittfield & Jeitner, 2015), in terms of its long-term viability, employment potential, and impact on the liveability and social sustainability of the community (Schafft & Biddle, 2015,). Their scepticism mirrored concerns about "unwanted consequences to the environment and human health, or economic losses due to the need to abandon or rework costly initiatives" (Goldstein et al, 2014, p. 271) from toxicologists.

2.3.2 Psychosocial.

For communities, many of them First Nations, situated proximal to the Athabasca oil sands, the extraction of oil is equally contentious (McLachlan, 2014). Each of the process and production stages (surface mining, separation, and refining) is associated with substantive environmental and water contamination from *priority pollutants* (industrial heavy metals and PAH's), and damaging health effects for children and youth (McLachlan, 2014). Since these oil sands are primarily located on First Nations lands in Canada, sociocultural, economic, and environmental factors intersect to exacerbate the risk to indigenous children and youth (Association of First Nations, 2008; Gamu, Le Billon & Spiegel, 2015). Wider psychosocial implications are also evident in this context, where stressors from cultural/historical alienation, poverty, and chronic under and unemployment impact children and youth's wellbeing.

Similarly, landscape degradation and/or the en/forced relocation of families and communities to construct dams for hydroelectric power disrupt cultural attributes and social identities associated with a place-based community (Littlefield, Dorricott & Cullon, 2007; Mactaggart et al., 2016; Sangaramoorthy et al., 2016). Young people's

sense of personal identity and community belonging is especially vulnerable to this kind of "collective trauma" (Perry, 2012).

2.3.3 Economic.

A *resource curse* is a scenario where resource-rich communities experience low incomes and social wellbeing (Torres, Alfonso & Soares, 2013), as represented by the Canadian oil sands industry (McLachlan, 2014), and at a community level in mining communities in Australia. Research into the relationship between mining and socioeconomic wellbeing by Hajkowicz and colleagues (2011) demonstrated that energy resource extraction industries positively impacted various quality of life indicators, such as income, housing affordability, education, and employment (Marchand, 2012), across regional and remote Australia. However, since other studies identified negative socioeconomic consequences for sub-groups within the sector (Banks, 2009; Lee, 2015; Rolfe, 2013), the authors inferred that in Australia, "regional benefits mask highly localised inequalities and disadvantage." (Hajkowicz et al., 2011, p. 30)

This review also suggests that disadvantage and inequality underpin much of the evidence related to the impact of energy resource activities on children and youth, at individual, family, and community levels[6]. The concluding section introduces the nascent literature about young people as *change agents* (Ponton & Andrade, 2007), in the context of energy production and global climate change.

3. Broader Impacts

In addition to the specific impacts outlined in the sections above, there are more general implications for children and youth, both positive and negative, of energy

[6] A synthesis of this research at a wider global level exceeds the scope of this review.

resource extraction. There is little doubt that these industries can provide significant employment opportunities for youth. This is particularly relevant for youth living in First Nations communities where the youth population is growing rapidly and unemployment rates average at 23 percent (Bains, 2013). However, these activities also imply a range of indirect adverse impacts children and youth related to impacts on their families and communities. Oil and gas activity can be associated with increased levels of within and between community conflict, land acquisition and appropriation, increases and unpredictability of in- and out-migration related to the boom and bust economies, increased disaster risks, and a range of cultural implications associated with disruptions to traditional activities, thus exacerbating existing sociocultural health disparities of Indigenous people (Tenenbaum, 2009; Wernham, 2007). Few of these studies have focused on youth, but those that have reveal similar disruptions to culture and sense of place (e.g., Spyce, 2009).

4. Youth as Agents of Change in the Context of Energy Production and Climate Change

Whereas children and youth can exhibit a wide range of biopyschosocial effects when they are exposed directly or indirectly to energy resource activities, particularly those related to carbon-intensive energy systems, as indicated earlier in this report, they also need to be considered as citizens with rights, and as potential leaders and agents of change. In the body of literature (and others) analysed for this report, children and youth are most often framed one dimensionally in relationship to their vulnerabilities (health, social, economic, developmental) and, therefore, a population in need of protection (Mitchell, Tanner & Haynes, 2009). This contrasts with an emerging literature that

frames them as agents of change in their communities (Blanchet-Cohen, Mack & Cook, 2010; Ponton & Andrade, 2007). Consistent with socioecological theorising (Bronfenbrenner, 1977), children and youth are both recipients of influence of the multi-contextual systems that envelop them, and actors that are able, when provided appropriate opportunities and support, to alter and affect those systems. As such, research and policy has begun to acknowledge that youth may be an untapped resource in creating change in the face of social and environmental challenges including the transition to low and no-carbon energy systems. For instance, the United Nations (UNICEF, 2013) has repeatedly emphasised the importance of engaging young people in sustainable development processes and climate change adaptation globally, since "the combination of youth and innovation has the potential to create solutions to development challenges and to transform societies" (United Nations Development Programme UNDP, 2014). In short, youth stand poised as a significant sustainability and resilience multiplier.

4.1 Youth engagement and activism in response to energy activities.

Although there is limited research describing youth's perspectives on, and resistance to carbon-intensive energy extraction and production, the existing studies demonstrate that youth both desire, and are able to take action, as in the role of Aboriginal youth in speaking out against pipeline development in Canada[7] (Nuttall, 2008). The form and degree of youth engagement is diverse and expanding, with examples ranging from attending meetings, peer-to-peer networking and exchanges (Wall, 2015), protests, national and international forums, to communicating with social media such as Twitter (White, 2013).

[7] Oil and natural gas is transported across northern Canada in pipelines to seaports, from where it is tankered to the US.

Other youth engagement activities in response to oil and gas have involved peer-to-peer networking and exchanges. A student network in Britain ("People and Planet") invited youth from the Beaver Lake Cree Nation in Alberta to speak about their perspectives on how the oil sands had impacted them. Following this, the UK students travelled to Alberta to highlight and protest the impacts of the oil sands industry on First Nations Communities using a public theatrical demonstration (Wall, 2015).

Some youth movements have been more disruptive. In Nigeria's Niger Delta, youth's insurgency and resistance to the development of the oil industry has been attributed to the neglect, marginalization and unemployment of youth and the widespread ecological damage that has destroyed local economies (Ikelegbe, 2001). Peaceful protests that were not addressed by state and oil companies eventually sparked widespread unrest and led to militancy. Youth groups threatened or attacked oil companies, took oil workers hostage, and vandalized pipelines (Ikelegbe, 2001; Iwilade, 2015; Ukiwo, 2007). More recently, the Niger Delta Development Commission and the Ijaw Youth Council (IYC) are calling on youths to protect pipelines and move towards positive action and dialogue (Harcourt, 2016).

These (selected) examples reaffirm and support this evolving social movement– young people are potentially powerful actors in developing and implementing the transition to a low carbon goods and services economy in Canada and globally. However, more research is needed to document and analyse the various modes of youth engagement and resistance to energy resource activities; in particular, the motivations; individual, community, and sociopolitical impacts; and *best* policies and practices to support these initiatives.

Knowledge Gaps and Areas for Future Research

This knowledge synthesis has described a range of health impacts of energy extraction and emissions on children and youth, and it has also offered preliminary support for the notion that young people can be active agents of change in response to industry activities and climate change impacts. Based on this review, a number of gaps and areas for future research can be delineated.

The majority of the reviewed studies described the *biological* health effects of energy systems on children and youth, rather than *psychosocial* outcomes. This calls for a number of additional psychosocial-relevant areas of study, such as examining connections between energy-related activities and youth well-being, exploring children and youth's lived experiences of growing up in energy dependent communities, and importantly, identifying the protective and promotive psychosocial factors that can increase children and youth's resilience despite exposure.

Another gap is that most of the literature is descriptive, documenting the negative health impacts of energy extraction and emissions on young people, but rarely examining interventions. In order to best inform policy and practice, additional studies are needed to explore the ways in which various technologies, policies, urban planning, and other strategies can minimize such negative effects.

A related issue with descriptive research is that linking energy extraction and emissions to biopsychosocial health is challenging, in part because it is difficult to demonstrate a *causal* relationship between the energy-related antecedents and the health-related outcomes; children and youth's health is determined by multiple confounding factors beyond energy systems. In addition, this type of research does not lend itself well

to a causal study design, given that young people cannot be randomly assigned to varying environmental conditions. One partial solution is to conduct more research using longitudinal designs, in which exposure and health outcomes can be assessed over time.

Over the course of conducting this synthesis, it also became apparent that very little is known about the biopsychosocial impacts of **renewable energy sources** (e.g., solar, hydro, and wind) on children and youth. Given that a transition to a low carbon economy, including renewables is underway, research is needed to identify these potential impacts, both positive and negative, so that efforts may be directed towards maximizing the positive impacts while minimizing the negative.

This synthesis also revealed that the majority of the research in this field is concentrated in particular contexts, such as Australian mining communities, and communities in close proximity to particular extraction-disaster sites (e.g. Chernobyl, Fukushima etc.). In addition, few of the reviewed studies focused on the Canadian context, and surprisingly, we found very little in our search parameters that addressed the major Canadian oil sands projects. This points to the need for more Canadian-specific research on oil sands projects as they relate to biopsychosocial health impacts on children and youth.

In the majority of the current research that does exist, the voice of children and youth is, for the most part, absent. Recognizing the agency of youth and the largely untapped potential of youth as changemakers in their communities, there is a need for more research that actively seeks to engage youth, capturing youth voices and perspectives. Case studies would be a useful starting place for documenting the range of youth-led initiatives and the conditions that have supported them. This would be

supported by research that is participatory in nature, with a focus on building the capacity of youth to engage in research and policy development in ways that are meaningful and sustainable. Additional research is needed to examine the motivations, individual, community, and sociopolitical impacts, and best policies and practices to support these initiatives.

Knowledge Mobilization Plan

The results of this knowledge synthesis will be disseminated through multiple platforms to ensure that the synthesis and its recommendations are accessible to the range of stakeholders engaged in or impacted by the energy sector (Kaster et al., 2012). The goal of the Knowledge Mobilization (KM) plan is to engage and encourage knowledge exchange amongst external academic researchers, policy makers, communities (including youth), industry stakeholders and the ResiliencebyDesign Network (RbDN). Representatives from the RbD lab will attend the SSHRC meeting in June to share preliminary synthesis structure and findings as well as learning from other KM activities and incorporating new and innovative approaches into the full synthesis and its KM products. The full synthesis will be shared online through the RbDN. RbDN is a growing network of academics, non-governmental organizations, youth and communities with an interest in youth, resilience, disaster risk reduction, climate change and social innovation in these interconnected fields. The **full synthesis** will also be posted on the ResiliencebyDesign website (under development) with an **executive summary**.

Previous experience of the research team has highlighted the importance of sharing research findings in ways that are accessible and relevant to research users. (See

www.ycdr.org for an example of a web-based KM platform developed by team members. Results will also be shared on existing social media platforms www.RbDyouthinnovation network and @ResiliencebyD). A series of **short videos/digital stories and community-oriented webinars** will be created to:

a) Share the general findings of the Knowledge Synthesis
b) Suggest future directions for research and action at the community and policy levels, nationally and internationally.
c) Make the results of the KS accessible to youth and communities in a way that is engaging and relevant and raises the profile of the findings.

The results of the KS will also be also be disseminated to academic audiences via one or two peer-reviewed articles to be published in relevant journal such as *Global Environmental Change,* as well as through presentations at a scholarly conference in the fall.

Conclusion

This knowledge synthesis is the first to review and summarize the effects of energy systems on children and youth's biopsychosocial functioning. Although relatively few studies have specifically focused on children and youth in this context, those that have uncover a range of negative health impacts directly and indirectly related to the development and ongoing operations of energy resource activities, particularly carbon-intensive energy industries, such as oil and gas, coal, and nuclear energy. Psychosocial and cultural effects, however, remain largely unexamined. Children and youth are also largely absent from the research on renewable energy systems. In addition, where children and youth are present in this literature, a vulnerability lens is primarily adopted.

This fails to acknowledge and integrate a consideration of children/youth rights including their right to participation. Taken together, this synthesis underscores the importance of including children and youth in future research and in the decision-making processes and policies that shape that research, energy resource activities and the transition to renewable and low-carbon energy systems. This review supports the emerging literature on youth engagement and empowerment, suggesting that the inclusion of young people in research and policy development should not only focus on understanding and addressing their vulnerabilities to the impacts of energy systems, but also on their potential as leaders and change makers in shaping the landscape of energy resource activities. In the context of climate change, youth stand as a largely untapped and significant resource and as potential innovators in the transition to a low-carbon society.

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