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Health Effects of Oil Spills and Implications for Public Health Planning and Research

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Introduction

Two major pipeline projects have been proposed to transport petroleum products from Alberta to the British Columbian coast. Despite potential economic benefits, these proposals have roused widespread public concern regarding the health and ecological consequences of a major marine or terrestrial spill. In Metro Vancouver, the Trans-Mountain pipeline expansion will triple the volume of petroleum products entering this densely populated urban area. In 2014, local municipalities requested Vancouver Coastal Health and Fraser Health to gather information on the potential impacts of oil spills on human health. What follows is a summary of literature reviewed on behalf of the Office of the Chief Medical Health Officer, Vancouver Coastal Health.[1]

Background

A Greater Vancouver-Area Health Authority reviewed oil-spill related research in order to inform the assessment of Vancouver and other BC municipalities of pipelines and coastal petroleum transport off their shores.

Methods

The review included epidemiological and sociological studies examining the short- and long-term impacts of oil spills. Various combinations of the key words related to potential impacts, impact

Key Messages

Physical Health Impacts

The academic literature shows statistically significant associations between oil spill exposure and a number of short- and potentially long-term physical health impacts, particularly among spill clean-up workers.

Mental Health and Community Health Impacts

Evidence of mental and community health effects is growing, and may affect a wider population base (individuals, families, and communities) with potential long-term effects.

Mitigating Health Impacts

Health impacts may be mitigated through the use of personal protective equipment, additional health service provision, and the alleviation of financial uncertainty through timely, rapid, and fair compensation, as well as policies that promote social support.

Implications for Public Health Planning and Research

The literature highlights an urgent need for proactive policies to evaluate and treat the short-term impacts on paid and volunteer clean-up workers and the general population, as well as the commitment of long-term funding to monitor and manage long-term impacts as they unfold.

populations, and specific spills were used to search Web of Knowledge, PubMed, and Google Scholar. Relevant studies were also identified through first round review of documents. Although this study relied primarily upon the peer-reviewed academic literature, government reports related to response efforts were also included.

Physical Impacts

Numerous studies have focused on acute physical impacts among oil spill clean-up workers, who are presumed to be the most severely exposed group. Impacts include headaches, respiratory symptoms (cough, wheezing, breathlessness), gastrointestinal symptoms (nausea and vomiting), and irritated eyes and throats.[2–8] The risk of experiencing acute effects was related to the total duration of work[3,6,8] and working in a highly polluted zone.[3,6] The risk for particular symptoms also varied according to the task performed during clean-up.[6]

Only a single study examined the duration of specific symptoms, revealing that the most prevalent symptoms – headaches, neurovestibular symptoms, and respiratory symptoms – persisted for a mean duration of 8.4, 6.9, and 2.1 months, respectively.[9] These data demonstrate that although acute effects are generally considered "short-term" and reversible in exposed workers, some symptoms may persist for months, with potential impacts on quality of life and health care service utilization.

Less is known regarding the long-term effects of spill exposure in workers. However, a series of studies carried out after the *Prestige* spill detected persistent respiratory effects indicative of airway injury up to 5 years after the spill.[10–13] Similarly, research revealed evidence of endocrine disturbance (altered prolactin and cortisol levels) up to 7 years after the spill,[14,15] although the clinical significance of these findings is not clear. At present, there is no evidence of teratogenic or carcinogenic effects in humans exposed to oil spills, although a number of studies have noted genotoxic effects in those who had participated in clean-up work up to two years after the accident, compared to people who had not participated.[13,16,17] However, genotoxic effects were not detected in a smaller study carried out seven years after the spill.[18]

Much less is known regarding effects in residents who are not directly exposed to spilled oil (e.g., inhalation exposure only during daily indoor and outdoor activities). However, although these individuals are less exposed than clean-up workers, the general population also includes more vulnerable individuals, such as the elderly, children, and those with pre-existing health conditions. In the *Braer* and *Sea Empress* accidents, researchers noted a range of self-reported acute symptoms (headaches and eye and throat irritation),[19,20] although in the former study these symptoms resolved quickly and were not associated with changes in respiratory, liver, or renal function, or biological indicators of toxicity. During the *Tasman Spirit* accident, the prevalence of acute symptoms (sore eyes, dry sore throat, cough, headache, irritability, fever, and fatigue) decreased with increasing distance from the shore.[21] There are currently no long-term studies on health impacts in residents.

Mental Health and Community Impacts

Research on spill-related mental health impacts is growing rapidly. Unlike physical impacts, which appear to be greatest among healthy adult clean-up workers, mental health impacts affect individuals, families, and communities and are less bound by proximity to the spill. Negative mental health impacts were observed within four weeks after the *Sea Empress* spill;[20] perceived risk or "psychological exposure" was more predictive of anxiety and mental health impacts than actual physical exposure.[22] Similarly, direct contact with spilled oil was not necessary to observe mental health impacts in coastal residents after the *Deepwater Horizon* spill,[23] demonstrating that the mental health impacts of a spill may be much broader than expected.

A large body of work carried out after the *Exxon Valdez* spill showed that individuals more severely impacted by the spill, in terms of impacts on livelihoods or contact with spilled oil, were at greater risk of generalized anxiety disorder (GAD), post-traumatic stress disorder (PTSD), and depression.[24,25] Depression was particularly marked among indigenous people and women.[25,26] Furthermore, indicators of post-traumatic stress, depression, and anxiety remained elevated for 1.5 to 8 years after the spill,[27,28] signaling the long-term impact that such disasters can have on mental health. Investigators also noted other indicators of social disturbance at the community level, including decreased social visiting and perceived increases in substance abuse and intra-personal conflict.[24]

During the recent *Deepwater Horizon* spill, a large-scale, population-based survey presented conflicting results regarding mental health impacts on Gulf Coast residents.[29] However, studies focusing on vulnerable communities (e.g., those dependent on fisheries or the oil and gas industry) found that living close to the spill impact area was significantly associated with increased symptoms of post-traumatic stress, depression, and anxiety.[30] Furthermore, community members who suffered income loss reported clinically significant levels of anger, fatigue, depression, tension/anxiety, and confusion compared to income-stable residents,[23,31] and in one study these effects intensified over time.[32]

Finally, mental health impacts due to oil spills have been observed in children, even though children rarely have contact with spilled oil. Children, especially girls, living close to the impacted coastline during the *Hebei Spirit* spill showed elevated symptoms of depression.[33] On the Gulf Coast, children whose families had been impacted by the spill showed various indicators of mental distress (sadness, fear, sleeplessness, etc.) compared to non-impacted children, and these effects were exacerbated among low-income and African-American families. However, research in this area is still lacking, and much further work is required to understand the short- and long-term mental health effects of oil spills on children.

Mitigating Health Impacts

Increasing Health Services Provision

Very few studies have addressed the public health response of past oil spills. In past spills, small increases in hospital and clinic visits have been observed as victims seek treatment for some of the short-term physical impacts mentioned above.[20,34] However, very little information is available regarding any increased need for mental health services post-spill,[29] although this need may be great.[35] For example, during the *Exxon Valdez* recovery, increased use of social services was reported.[36] This points to the need for flexible and scalable provision of health services following a spill.

Personal Protective Equipment (PPE) and Safety Training

Multiple studies have shown that the proper use of PPE, especially an appropriate mask, can markedly decrease the prevalence of acute physical symptoms,[3,8,10] including specific neurological (headache, nausea, dizziness, fatigue) and respiratory symptoms. Use of an appropriate waterproof suit also reduces the risk of a number of toxic effects, including genotoxic effects and heavy metal contamination, as well as the risk of physical injury (scrapes and rashes).[6,8,16]

Unfortunately, many previous studies found that few workers use a full complement of PPE (mask, gloves, waterproof suit, and boots), highlighting the need for pre-deployment safety training for clean-up workers. Carrasco et al.[4] found that workers who received health and safety training were more likely to use a full complement of PPE, were less likely to report broken/damaged equipment, and were at lower risk of experiencing acute symptoms.

Alleviating Financial Uncertainty

Broader economic or personal financial uncertainty is linked with mental and community health impacts post-spill.[22,23,28,32,37–39] However, during the *Prestige* spill in Northern Spain, those individuals most highly impacted showed an unexpected decrease in depressive symptoms compared to their less-impacted peers.[40] Follow-up studies suggested that attenuated effects among the most severely impacted may have been due to the fact that these individuals were most likely to have received compensation,[41] which during the *Prestige* crisis was initiated relatively rapidly. These data support the notion that decisive action to counter financial uncertainty may have mental health benefits post-spill. In contrast, the need to fight for compensation and perceived injustices in compensation awarded may exacerbate ill effects. For those affected by the *Exxon Valdez* and *Deepwater Horizon* spills, being involved in long-term litigation was associated with a host of negative outcomes, including increased stress, work disruption, perceived damage to the community, and intra-communal conflict.[28,42,43]

However, compensation is not a magic bullet for post-spill recovery. In the *Exxon Valdez* spill, increased income from clean-up work led to social disruption by creating a wealth imbalance within small communities.[24] Furthermore, compensation may be less effective in communities where the value of the resource lost is difficult to quantify (i.e., value of lost country foods or subsistence activities and subsequent cultural deterioration),[36] or where the notion of assigning fixed values is distasteful or inappropriate.[43] At the community level, it has been suggested that

reliance on compensation may in fact decrease the resilience of communities to future disasters.[44]

Social Support

As with financial uncertainty, the perception or perceived lack of social support has been linked with the severity of mental health impacts. Along with increased satisfaction with compensation, individuals who were highly impacted by the *Prestige* spill and yet did not demonstrate an increase in depressive symptoms reported feeling a higher degree of social support compared to less impacted but more depressed individuals.[41,45] In contrast, oil spill exposure was associated with the deterioration of social networks, as measured by decreased social visiting and less participation in community, religious, and volunteer events, in small Alaskan communities affected by the *Exxon Valdez* spill.[24,46] In addition, as mentioned above, perceived unfairness in compensation may provoke intra- and inter-communal conflict.[23,36,43]

Implications for Public Health Planning and Research

Although the body of literature dealing with the health effects of oil spills has grown, less has been written about the public health policy implications of oil spills. However, from the available literature, past spills do provide some guidance on critical knowledge gaps and planning considerations to minimize health impacts.

Preparation for Voluntary and Paid Clean-up Work

In some past spills, hundreds of thousands of people have engaged in clean-up work of some kind, presenting logistical issues for protecting these potentially highly exposed individuals. However, a great deal of information on managing a large-scale cleanup has been gathered by NIOSH and OSHA, the two agencies primarily responsible for training ~100,000 workers during the *Deepwater Horizon* spill. Their comprehensive approach included creating a worker database (including volunteers) and providing pre-placement health evaluation, job training, and health monitoring and post-response follow-up.[47,48]

Launching Broad-Based Public Health Surveillance

As with any disaster, the public health response to an oil spill must be scalable, cost-effective, and broad-based, with appropriate emphasis on variables of interest as identified here. To avoid response delays, a bank of physical and mental health assessment protocols (and expertise)[49] should be prepared in advance. Such tools are necessary to collect detailed information from the impacted population, including demographic information, health histories, detailed exposure information, and information on other potential exposures, etc. These data are necessary for the creation of a *health surveillance database* for workers and residents, both for assessing the situation as it unfolds and information-sharing among agencies, as well as for future follow up research.[6,47,50]

The marked, long-lasting mental health and community impacts of oil spills highlight the need for an integrated response that recognizes these impacts explicitly and mobilizes the appropriate interdisciplinary expertise to provide timely and culturally appropriate services.[39,51,52] Past experience in the *Deepwater Horizon* spill showed the utility of adopting novel, flexible models for mental health care that facilitated access for both urban and remote communities.[51] Special attention should be paid to the most vulnerable groups: those who depend on natural resource base affected by the spill (i.e., fisheries, tourism, etc.), indigenous populations, and under-researched populations (children).

Risk Communication

Oil spill disasters present a risk communication challenge due to their high media visibility and complex but uncertain health and ecological risks.[53] Traditional, top-down risk communication (based on toxicological data and expert opinion) were somewhat ineffective during the *Exxon Valdez* and *Deepwater Horizon* spills, leading to fears over seafood safety and dire effects on the seafood industries and dependent families.[37,38,43,54,55] This points to the need to better engage the public in order to devise innovative and effective risk communication approaches for oil spills. Previous work has demonstrated the utility of using a mental models approach for designing risk communication strategies[56] and the value of engaging the public through interactive web-based simulators.[57]

Designing and Funding Long-term Research

Despite the urgent need for more data on the health impacts of oil spills, research needs are often

overlooked during a crisis. In past spills, authors have noted the utility of a designated task force to coordinate and design oil spill research.[50,58] Furthermore, the limitations of past oil spill health impact studies should be considered when planning future public health research. These limitations include the following:

- Lack of information regarding the duration of acute symptoms, which may persist over many months,[9] or their effects on quality of life.
- Strong focus on clean-up workers, who may be healthier than the general population, raising questions regarding effects on more vulnerable, under-studied populations, such as the elderly, children, and those suffering from pre-existing conditions (e.g., asthma).[59,60]
- Lack of baseline health data makes generating meaningful post-spill comparisons difficult.[30,31,61] It is unreasonable, however, to expect pre-spill data collection for every potential parameter of interest.
- Lack of rigorous exposure characterization through environmental monitoring or human biomonitoring. Often, the available data does not demonstrate changes consistent with the observed health impacts[2] and/or may not be appropriate for decision making. Accordingly, the use of personal exposure monitoring should be included in oil spill response planning.

Finally, lack of rapid access to funding is hugely detrimental to capturing both short-term impacts, as well as pursuing vital, but costly, long-term impact studies.[49] Most previous oil spill health impact studies were funded on an ad hoc basis through institutional or government grants. A notable exception are the large voluntary and court-mandated contributions made by British Petroleum to study the health and ecological effects of the *Deepwater Horizon* spill.[62–65]

Conclusions

The literature reviewed presents suggestive (although not causal) evidence that oil spills are associated with short- and perhaps long-term health impacts in highly exposed adults (i.e., clean-up workers), as well as long-term mental health effects in individuals and communities directly and indirectly impacted by spills.

However, although the location of the pipeline, the product transported (bitumen, crude, or refined petroleum), the extent and duration of the spill, capacity for ongoing and emergency clinical care, and public reaction are expected to influence health impacts in workers and perhaps residents, the lack of information available does not allow for assessment of these factors. The review findings and these gaps in knowledge highlight the critical need for public health surveillance, long-term health research, and related policy development to prepare for potential future oil spills.

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