Occupational Asthma among Workers in the Crab Processing Industry: A Review of the Literature

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Abstract

Current literature suggests that those working in the crab processing industry, are at increased risk of developing occupational asthma. Anecdotal evidence suggests that this may be a health concern among female, H2B migrant workers laboring in blue crab processing facilities in eastern North Carolina. These are consistent with reports from other areas where vulnerable and often rural seasonal workers experience a disproportionate level of exposure to crab antigens and related occupational asthma. This paper will review the current literature addressing workplace asthma and related conditions experienced by workers working in shellfish processing facilities. Specifically, it will evaluate the current literature regarding crab-packing facilities and the potential asthma-like symptoms experienced by workers in those environments. Attention to the nature of the exposures, reported pathophysiology, gender bias, related mechanical injuries, psychosocial issues, and legal aspects of the condition will also be described. As the majority of the studies addressing this topic were completed in the late 1980s and 1990s, direction for potential future studies will be provided. Preliminary prevention method recommendations will also be made for those currently working in applicable settings.
Background

**Previous Cases.** In 1965, asthma-like illnesses among crab workers were first identified in an unpublished report by Dr. David Discher. The next report of such symptoms among crab-processing workers came in 1979 when 17 cases of asthma and rhinitis were found among queen crab processors in Newfoundland. The next was in 1982 when 46 workers in the Dutch Harbor area of Alaska presented to a family health services clinic with asthma-like symptoms consisting of dyspnea and wheezing. In this incident, the approximate incidence rate for “crab asthma” was found to be 2 cases per 100 workers per month, at least 80 times the monthly incidence of new cases of asthma and 8 times the incidence of new cases of bronchitis among similar groups of Americans at that time.

Additional reports followed thereafter with the next occurring in 1984 in Iles de la Madeleine, Canada. In this investigation, researchers found that 15.6% of snow-crab processing workers developed occupational asthma, a diagnosis which they confirmed through specific inhalation challenges and/or a combination of changes in spirometry, bronchial responsiveness to histamine, and changes in peak expiratory flow rate.

In 1985, reports of crab-related occupational asthma moved beyond snow and queen crabs to include king crabs. Researchers in this investigation found that the sera of 9 out of 15 crab-processors showed precipitins when exposed to extracts of crab meat, shell, and processing dust. Findings of controls from a fish-packing plant showed no reaction. Through their research, the investigators concluded that inhaled crab antigens were likely causing the immunologic effects and respiratory symptoms.

A 1998 report showed that crab-induced occupational asthma could also be seen in tanner crabs, which are closely related to opilio crabs; both species are often referred to together as
snow crabs. Unlike the previous studies concerned with workers in shore-based processing plants, this study evaluated workers from offshore processing vessels where workspace was more compact, and personal exposure to crab antigens more intense. The researchers found that workers exposed to nebulized juice from crab-cooking vats experienced significant decreases in pulmonary function. They also found that a specific IgE antibody indicated sensitization among the workers.  

In 1999, Atlantic rock crab was added to the list of species confirmed as being capable of causing occupational asthma when 7 out of 28 subjects had a positive skin reaction to rock crab extract. In addition, a high prevalence of asthma-like symptoms among the study population indicated that workers were at high risk of developing occupational asthma related to their work.  

While additional studies have been completed which evaluate crab-induced occupational asthma, they were conducted in settings and with species already described above. Therefore, these studies will be evaluated in subsequent sections related to their primary contribution.  

**Exposure Mechanisms.** As the following discussion of exposure mechanisms relies heavily on the organizational scheme of crab processing facilities, refer to Figure 1 below from the 1997 Malo et. al. study which generally describes the flow of work in a processing facility.
Figure 1. General processing plant scheme as reported by Malo et. al. in 1997.\(^8\)

As indicated above, the prevailing opinion after 1985 was that workers were exposed to airborne antigens.\(^5\) In 1994, researchers were able to determine that even low airborne crab antigen concentrations caused respiratory sensitization of workers in a snow-crab processing plant where 23% of workers had work-related respiratory symptoms and 37% had crab-meat specific IgE antibodies. The researchers used high volume air samplers to collect air from various locations within a processing facility which was then analyzed for total protein and crab-specific antigens. They found that in areas where crabs were being processed, concentrations of crab antigen ranged from 9-115 ng/m\(^3\) of air while in other parts of the facility no more than 4 ng/m\(^3\) was found. They concluded that the antigens rapidly settle and tend not to drift into adjacent areas.\(^9\) Prior research had shown that 30% of these antigens were of respirable size.\(^5\)

Subsequent research showed that it was the boiling component of the crab meat packing process that caused antigenic proteins to become airborne and that inhalation led to sensitization, though introduction through skin and the gastrointestinal tract were also cited as potential minor routes of sensitization.\(^8\) A follow-up study used immunoassays to confirm these results and showed that high aerosolized antigen concentrations extended beyond the boiling area and into the cooling basin area (the next step in the crab processing) as well.\(^10\)

A 2002 study concluded that in the tight work spaces of processing vessels, exposure to high concentrations of airborne antigens is more ubiquitous. This leads to high levels of reported respiratory symptoms among workers in all job categories despite any variations in airborne antigen concentrations that may exist.\(^11\)

**Reported Pathophysiology.** Several studies have reported the occurrence of occupational allergies and respiratory symptoms. One review of such allergies among seafood
industries from 2001 reported findings among workers handling crabs, prawns, mussels, fish, and fishmeal. Among the studies reviewed, the prevalence of occupational asthma ranged from 7% to 36% and for occupational protein contact dermatitis ranged from 3% to 11%. In both cases, symptoms were attributed to exposure to high molecular weight antigenic proteins. A prior industry-wide review had also implicated the role of such proteins in occupational asthma in crab workers. Further, the particular proteins implicated in development of occupational asthma are suspected of containing homologous structure across multiple genera of crab species, thus explaining reactivity to extracts of crab to which individuals were never exposed.

Published reports currently indicate that in the crabbing industry, occupational asthma occurs through an IgE mediated pathway due to the abovementioned highly soluble, airborne, antigenic, high molecular weight proteins released during processing, especially during the boiling phase. Similar mechanisms of occupational asthma development have been shown among workers handling platinum salts, laboratory animals, trimellitic anhydride, Bacillus subtilis, red cedar, and isocyanates. Current research also suggests that the extent of reaction development and associated symptomology may be dependent on a combination of both process-related exposures and personal risk factors and that both allergic and non-allergic mechanisms are likely to be involved.

The long-term effects of occupational asthma due to crab antigen exposure have been less fully evaluated than the acute effects of the condition. One follow-up study from 1985 indicated that crab-induced occupational asthma may not be fully reversible as was previously thought and that subjects may experience persistent symptomology, airway obstruction, and hyperexcitability up to two years after exposure is removed. According to the researchers, the duration of exposure after symptoms first present is highly reflective of the long-term reversibility of lung changes.
A separate study subsequently confirmed that improvements in spirometry plateau approximately 1 year after exposure cessation while improvements in bronchial hyperresponsiveness plateau at 2 years out. The researchers also found that there was a concurrent decrease in IgE titers during these periods, but that no plateau was reached. In addition, it has been shown that allergic responses to crab antigen that develop through inhalation of airborne proteins can transition to a subsequent food allergy with gastrointestinal symptoms.

**Gender Bias.** The high number of women experiencing occupational asthma related to crab processing has been heavily cited throughout the literature. In a comprehensive analysis of this bias from a 2006 study in Newfoundland and Labrador, Canada, researchers determined that the bias is mainly the result of differential selection of job types within crab processing plants. Crab butchers, for example, tended to be male (89%), while cleaning and packing functions tended to be performed by females (66%). As indicated in previous sections, airborne antigen exposure levels vary throughout facilities and certain jobs functions like cleaning, cooking, and packing tend to have higher exposures as a result. The fact that workers in “female” jobs tend to experience higher exposures goes far in explaining the perceived gender bias. In addition to this however, the researchers in the 2006 study indicated that women were more inclined to report symptoms and to indicate that those symptoms were of higher severity than men. Because of the gender division of labor, it has been reported that females who experience exposure-related symptoms are less able to lower their exposure by changing jobs and may even be forced to bear financial burdens in order to do so. In studies regarding processing vessels, workers were predominately male, even for those roles typically held by females in shore-based facilities. A concordant rise in occupational asthma symptoms
resulted in these settings, but this is mostly attributed to the confined space and limited ventilation.\textsuperscript{6,11}

**Mechanical Injury.** Laborers in crab processing plants perform highly intense, repetitive motions throughout their shifts related to the butchering, cutting, cooking, and packing functions. The effects of such motions have not yet been significantly addressed in the literature in an industry-specific way, though parallels can likely be drawn from other similar industries such as fish processing. One study evaluated reports of pain among crab processors as a component of an investigation of asthma-like symptoms and found that back pain was reported by 33% of men and 48% of women and shoulder pain was reported by 23% of men and 47% of women.\textsuperscript{22} Another study reported that 53% of workers complained of back pain.\textsuperscript{19}

**Psychosocial Issues.** Two studies currently stand out as having addressed the psychosocial issues, health beliefs, and coping behaviors among crab-processing industry workers affected by occupational asthma. The first from 2003 found that the majority of workers (65%) felt that their symptoms were directly related to their work. In addition, they tended to understand the symptoms associated with occupational asthma (80%) and to have heard of “crab asthma” before (85%). The majority of workers (55%) had learned of the condition from fellow workers while a quarter had learned about it from their doctor or nurse (26%). Another quarter had learned about the illness from their union in this study (24%). 73% of the workers in this study indicated that they would see their doctor, 51% a specialist, and 51% a nurse.\textsuperscript{19} It is important to note, however, that this study was conducted in Canada where access to care is universal and both access and financial constraints may disincline workers in other areas to pursue such action. A second study from 2006 evaluated similar concepts and found that 60% of respondents (75% of women and 39% of men) associated “particular health problems with crab
plant workers.” The study also found that workers tended to believe that “people with crab asthma want to keep it a secret,” “you can die from crab asthma,” and people who smoke are more likely to get crab asthma.”

The current study and an associated unpublished thesis indicated significant life quality and socioeconomic impacts related to crab-induced occupational asthma, allergies to crab, and associated symptoms. In general, survey respondents were concerned with seeking help for their condition and with filing worker’s compensation claims because they felt the process was too difficult, would lead to insufficient or temporary assistance, cause them to lose work time and associated income, and/or make them ineligible for employment insurance.

**Legal Aspects of Occupational Asthma.** The need for OSHA policies regarding exposure to airborne antigens within crab-processing facilities was evident as early as 1994. At that time, a report identified the difficulty of OSHA compliance inspectors in Washington State in evaluating the safety of crab processing facilities when no such policies existed and workers were experiencing respiratory symptoms. Without proper guidance on acceptable exposure levels and appropriate preventive measures, enforcing change among plant operators is made difficult. A later study evaluating off-shore processing vessel inspections indicated similar difficulties. While recommendations regarding acceptable concentrations and requisite personal protective equipment for other industries and airborne antigens have been issued by NIOSH and OSHA, such recommendations have not yet been developed for soluble, high molecular weight antigenic crab proteins.

North Carolina administrative code has established substantial limitations to the operations of crab processing facilities in Title 15A (Department of Environment, Health, and Natural Resources), Chapter 18 (Environmental Health), Subchapter 18A (Sanitation), Section
.0100 (Handling: Packing: and Shipping of Crustacea Meat). Applicable codes range from .0101 to .0191. The majority of codes found here are designed to protect consumers from contaminated food products, however some may be applicable to the protection of workers from occupational asthma to a minor extent. For example, section 15A NCAC 18A.0143 states that “all rooms and areas shall be ventilated” in reference to processing facilities. 15A NCAC 18A.0161(a) further states that “the cooking area or room… shall be vented to assure the removal of steam” and continues on to say in subsection (c) that “venting shall be sufficient to permit the complete elimination of air from the retort” (which is a machine used in cooking). 15A NCAC 18A.153(g) may also prove relevant for those workers who experience occupational protein contact dermatitis as it states “the arms of personnel who pick or pack cooked crustacean or crustacean meat shall be bare to the elbow or covered with an arm guard approved by the division.”

It has been clear that employers are responsible for the short term costs of acquiring crab-related occupational asthma, but with the increasingly well-documented risks of long-term injuries discussed previously, the implications for crab-related occupational asthma on worker’s compensation claims is significant. Several studies have indicated the importance of this when describing the condition and have generally indicated that because of the permanence of some symptoms, there may be need for compensation due to permanent disability. Furthermore, surveys of workers have indicated that between 63% and 74% of workers were unaware of their eligibility to obtain worker’s compensation for their symptoms. As such, it is uniformly suspected that workers in this and other industry sectors dominated by vulnerable and often rural seasonal workers significantly underreport their symptoms and are resultantly undercompensated.

**Potential Interventions**
Although many workers exposed to airborne antigenic crab proteins experience symptoms that are reversible, given the permanence of occupational asthma and allergies for some, it is incredibly important that appropriate safety guidelines be established and enforced.\textsuperscript{15,17} Thus far, comprehensive recommendations for such guidelines have not been established in the literature or by regulating government entities beyond generally applicable multi-industry standards, which are often inadequate. References to potential methods of exposure reductions can be found in many reports, but specific details of appropriate methods of implementing these, and more importantly, analyses of their effectiveness are missing. Nevertheless, such methods will be evaluated here as a starting point for future inquiry.

Surveys of workers suffering from crab-related respiratory symptoms indicate that workers employ a variety of personal behaviors aimed at reducing exposure and symptoms when working in facilities with inadequate crab processing safety measures. Frequent coping strategies cited include the use of medications like antihistamines and inhaled steroids during breaks to reduce symptoms, leaving their work station to get fresh air, and wearing masks and multiple layers of clothing to keep crab dust away from their faces and skin.\textsuperscript{19,23} The latter method was indicated by workers despite the constraint of working in a relatively humid environment.\textsuperscript{19} These personal behaviors are inadequate responses given the severity of the health threat involved, yet remain the primary prevention methods for vulnerable workers with few options for recourse.

Process-level interventions are much more likely to result in reductions of exposure to crab dust for laborers. Proposed mechanisms found in the literature, which tend not to have been evaluated for effectiveness, include improvement of ventilation, more thorough cooling methods, enclosed boiling units, the use of air filters to remove generated aerosols, and programs to
discourage smoking.\textsuperscript{4,5,8} These largely process-oriented methods are needed for shore-based facilities, but are even more urgent for off-shore processing vessels where exposures are much higher.\textsuperscript{18,21} Taken together with the aforementioned use of personal protective equipment like respirators and gloves, it is likely that the incidence of occupational asthma and occupational protein contact dermatitis among crab processing workers could be substantially reduced. It is, however, unlikely that industry self-regulation will lead to such changes, further implicating the need for standard development by state and federal agencies. In addition, educational programs within processing facilities are needed to encourage the utilization and proper use of protective gear when it is optional for workers.

\textbf{Conclusion}

Cases of crab-induced occupational asthma have been reported for workers handling Alaska king, snow (opilio and tanner), Atlantic rock, and queen crabs and evidence suggests similar reactions are generalizable to other crab species like blue crab in North Carolina. It has also been shown that the workers which suffer from this condition tend to be women who are vulnerable to extrinsic socio-politico-economic pressures which limit their ability to cope with their illness in an effective manner and seek recourse for damages to their health when they occur. In addition, while the mechanism of action for airborne crab antigens has been well documented and exposures thoroughly described, adequate safety standards and industry regulations have not been set. Currently, only moderately affective personal behaviors among workers are utilized and broader, process-driven approaches to reduce exposures have not been evaluated.

Future work related to crab-induced occupational asthma should attempt to both broaden our understanding of the disease process and address the abovementioned gaps in the literature.
by focusing on: 1) the recognition of the illness in blue crabs in North Carolina, 2) the development of policies setting acceptable exposure levels, 3) establishing process-directed industrial interventions, 4) the evaluation of such interventions, 5) the use of newer technologies in evaluating affected individuals such a fractional exhaled nitric oxide (FeNO), 6) further evaluate the impact of socio-politico-economic factors on the psychosocial wellbeing of the affected, and 7) the combined impact of additional injuries and diseases, like mechanical damage from repetitive motions, which are likely to jointly affect vulnerable workers within the industry.
References


