



Gender and snow crab occupational asthma in Newfoundland and Labrador, Canada[☆]

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Abstract

Fish and shellfish processing employs many thousands of people globally, with shellfish processing becoming more important in recent years. Shellfish processing is associated with multiple occupational health and safety (OHS) risks. Snow crab occupational asthma (OA) is work-related asthma associated with processing snow crab. We present a gender analysis of findings from a 3-year multifaceted study of snow crab OA in Newfoundland and Labrador, Canada. The study was carried out in four snow crab processing communities between 2001 and 2004. An anonymous survey questionnaire on knowledge, beliefs, and concerns related to processing snow crab administered to 158 workers attending community meetings at the start of the research found that women were significantly more likely than men to associate certain health problems, especially chest tightness, difficulty breathing, and cough, with crab processing ($P < 0.001$). Worker health assessments carried out with 215 processing workers (187 current/28 former; 120 female/95 male) found that female participants were more likely to be diagnosed as almost certain/highly probable snow crab OA and allergy ($P = 0.001$) and to be sensitized to snow crab ($P = 0.01$) than male participants. Work histories from the health assessments were used to classify processing jobs as male or female. Allergen sampling (211 allergen samples: 115 area, 96 personal breathing zone) indicated that the plant areas where these male jobs were concentrated were associated with lower levels of aerosolized crab allergens (the agents responsible for OA to snow crab) than areas associated with female jobs. This difference was statistically significant in the two plants with poor ventilation ($p < 0.001$ and $P = 0.017$ for these plants). A gender analysis of work history data showed that female health assessment participants were likely to have worked longer processing snow crab than males (5 years versus 3.5 years, respectively). Cross-referencing of work history results with allergen sampling data for male and female job areas showed a gender difference in median cumulative exposures (duration of exposure $\times$ level of exposures) for health assessment participants. Health assessment participants with estimated higher median cumulative exposures were more likely to receive a diagnosis of almost certain/highly probable OA and allergy. Semistructured interviews with 27 health assessment participants (24 female/ 3 male) with a diagnosis of almost certain/highly probable or possible snow crab OA indicated that these workers can experience substantial quality of life impacts while working and that they seek to reduce the economic impact of their illness by remaining at their jobs as long as possible. Indications of selection bias and other study limitations point to the need for more

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research exploring the relationship between the gender division of labor and knowledge, beliefs, and concerns about snow crab processing, as well as gender differences in prevalence, quality of life, and socioeconomic impact.

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1. Introduction

Fish and shellfish processing provided a growing source of employment globally between 1970 and 1990, with the rate of growth of shellfish processing outpacing that of fish processing (Jeebhay et al., 2004). Some shellfish processing takes place on board factory vessels, as in the case of snow crab in Alaska and shrimp in Newfoundland and Labrador. In northern areas, onshore shrimp and crab processing is often located in remote communities where workers have limited access to alternative employment, as well as to health services, particularly specialists. As with other rural and marginal workers, there is limited research on the occupational health issues they confront. Internationally, shellfish processing workers are often female, seasonally employed, and poorly paid and, as with other seasonal activities, a growing proportion are migrant or “guest” workers moving within and between countries, thereby contributing to economic uncertainty and vulnerability (Diaz, 2005; Vidal, 2005).

Industrial fish and shellfish processing is associated with a broad range of workplace hazards. Occupational asthma (OA) and allergy are associated with bony fish and particularly shellfish processing (Jeebhay et al., 2001). Asthma is a respiratory condition that results in breathing difficulties. These breathing difficulties are associated with variable airways obstruction and bronchial hyperresponsiveness and inflammation. Snow crab OA is work-related asthma associated with processing snow crab. Snow crab OA is mediated through an allergic mechanism involving the production of specific immunoglobulin E (IgE) antibodies to crab meat and cooking water (Cartier et al., 1986; Malo et al., 1997; Weytjens et al., 1999). It is caused by exposure to crab proteins in dust, steam, and vapor generated by cleaning, steaming or boiling, washing, sawing, or crushing crab in processing plants. During these activities crab proteins can become airborne and penetrate the airways. Some workers respond adversely to these proteins by producing IgE antibodies that react with these crab proteins. This response is called sensitization and can develop after several weeks or over several years of exposure. When sensitized workers are re-exposed to crab allergens, they can develop symptoms that we associate with crab allergy, i.e., rhinitis (itchy, sneezy, and runny nose), conjunctivitis (itchy, watery, and red eyes), urticaria (skin rash), or crab asthma (chest tightness, wheezing, cough, difficulty breathing).

Research done in Quebec, Canada, in the 1980s indicated that in environments where regulations limiting exposures were absent and awareness was low, prevalence of snow crab OA was 15.6% in two plants that had been open for 2 years (Cartier et al., 1984). Workers with snow crab OA who continue to work using asthma medications run the risk of their asthma worsening and becoming permanent as a result (Chan-Yeung, 1987; Hudson et al., 1985; Malo et al., 1988). Socioeconomic impacts of snow crab OA are poorly studied, but existing research on OA in general suggests that they are likely to be significant (Malo et al., 1988; Moscato et al., 1999), especially for older workers, female workers, and workers lacking access to an effective system for diagnosis and compensation (Ameille et al., 1997; Chan-Yeung et al., 1987; Dewitte et al., 1994; Gannon et al., 1993; Malo, 1992; Marabini et al., 1993; Moscato et al., 1999; Neis, 1994; Pauli et al., 1996; Ross and McDonald, 1998; Venables et al., 1989; Yassi, 1988).

Both males and females work in snow crab processing but, as with other work environments, the relative proportions of males and females in the labor force can vary from place to place. In addition, males and females tend to do different jobs with potentially different exposure levels and the gender division of labor can vary from plant to plant and over time (Messing, 1998). Most previous research on snow crab OA has not explored the gender dimensions of this occupational disease. Research reports often contain no information on the sex of participating workers (Beaudet et al., 2002) or, where prevalence data are broken down by sex, the latter is treated as a potential risk factor in the absence of information on the gender division of labor and potential related differences in exposure and work history (Messing, 1998; Ortega et al., 2001). One exploratory study (Neis, 1995) of asthma-like symptoms among snow crab processing workers in Newfoundland and Labrador Canada carried out in the early 1990s indicated that in this province, women were most at risk of symptoms because of the concentration of women in the crab processing sector of the industry and the gender division of labor that limited women's ability to move to jobs with lower exposures once symptoms developed. However, this research was based on a small number of interviews with a nonrandom sample of symptomatic workers (Neis, 1995) who had not undergone testing for sensitization or OA and was subject to possible selection bias.

Table 1
Study components, data collected, date, and sample size

Study component	Data collected	Date	Sample (n)
Knowledge, beliefs and concerns	Knowledge, beliefs, and concerns questionnaire completed by workers, management, and health care professionals attending community meetings	2001	196
Worker health assessment	Medical history questionnaire; skin prick tests; RAST test; spirometry, PFM monitoring (pre- and post-return-to-work).	2001 2003	215 121
Allergen sampling	Area samples PBZ samples	June and July 2001	115 96
Cumulative exposures	Type and location of job Average allergen levels in job/plant areas	Collected in component 2 Collected in component 3	215 workers 211 allergen samples
Quality of life (QOL) and socioeconomic impacts	Semi-structured interviews	2003	27

This article¹ presents a gender analysis of the findings from a 3-year study carried out in four isolated single-industry crab processing communities in Newfoundland and Labrador on Canada's east coast between 2001 and 2004. At that time, there were between 38 and 40 licensed snow crab processing plants in this province, employing an estimated 5000–6000 seasonal workers. There was a twofold increase in the number of such plants between the early and late 1990s. The study had five main components (Table 1): (1) an anonymous knowledge, beliefs, and concerns questionnaire administered to workers, management, and health professionals during meetings in these communities held prior to the start of the research; (2) a worker health assessment component based on the administration of a medical and work history questionnaire, blood test, skin test, spirometry, and peak flow monitoring (PFM) during the off season and after return to work; (3) an allergen sampling component designed to identify levels of aerosolized allergens associated with different areas of the plants; (4) a cumulative exposures component in which we estimated median cumulative exposures for male and female participants in the health assessment component; and (5) a series of semistructured interviews with symptomatic participants in the health assessment component, intended to assess the quality of life and socioeconomic impacts of occupational allergy and asthma to snow crab among participating workers.

¹Preliminary worker health assessment results and results related to knowledge, attitudes, and beliefs about crab asthma (without a gender analysis) were published in the Proceedings of the 12th International Congress on Circumpolar Health, International Journal of Circumpolar Health 2004: 63, Suppl. 2 (Jong et al., 2003; Cartier et al., 2004). This paper is a revised and expanded version of a presentation to the conference Canadian Researchers in Women's Occupational Health (Howse et al., 2003).

2. Methods

Each component of this research was approved by the appropriate ethics committees. In all cases, participation was free and voluntary.

2.1. Knowledge, beliefs, and concerns component

We started the project with information sessions in each participating community with health care professionals, management, and workers. This opening session was used to explain what the project was about and who had funded it and to explain what crab asthma is, as well as the various study components. At the start of these sessions, before presenting the background information, we asked those attending the meetings if they would volunteer to complete an anonymous, self-administered survey questionnaires to assess knowledge, beliefs, and concerns about health issues related to processing crab. Questionnaire data were entered into spreadsheets and analyzed using the Epi Info program (Epi Info 2000, Centers for Disease Control and Prevention [CDC] 2000).

2.2. Worker health assessment component

Participation in this component was based on written, informed consent. Individuals could opt out of one or all of the different tests and final test results were confidential and provided to the participants only if they consented to receive those results. Participation was limited to those 19 years of age and older and both workers and former workers were eligible to participate. A list of names and phone numbers for current and former workers for the period 1999–2001 was provided by the participating companies. A community

Table 2
Diagnosis of occupational asthma

Diagnosis of occupational asthma	Symptoms of asthma	Skin tests with snow crab or RAST	PEF monitoring
Almost certain	+	+	+
Highly probable	+	+	N/D
Possible	+	–	N/D
Unlikely/negative	–	– or +	N/D or –

Note: +, Present; –, absent; N/D, not done.

coordinator attempted to contact people on these lists to see if they would be willing to make an appointment to meet with the researchers. In all four communities, many people on the lists could not be contacted, often because they were students who were away at school or adults who had moved away.

At the initial appointment, a registered nurse (RN) administered a medical and work history questionnaire that drew on existing OA questionnaires and included questions related to demographic information, work history, allergies, smoking history, history of ocular, nasal, skin, and respiratory symptoms at work and away from work, physician diagnosis, and medication use. A registered respiratory therapist (RRT) asked participants to consent to prick skin tests to four common allergens; atopy was defined as a positive reaction to at least one aeroallergen. Positive (histamine, 5 mg/ml) and negative controls (diluent) were also done. Sensitization to snow crab was confirmed initially by a skin test using extract derived from snow crab meat and results of an allergen-specific IgE antibody test (RAST) (to determine the presence of IgE antibodies directed against crab allergen) assays done on blood collected by the RN during individual appointments with the workers. Two RAST tests were done on each blood sample, one with an extract from cooked crab meat from Newfoundland plants and one with an extract produced from crab cooking water taken from one of the participating plants. Crab extracts were provided by Dr. Sam Lehrer from Tulane University, New Orleans, and RAST tests were done in his laboratory. The RAST test results indicated that the test with the extract made from the cooking water was more sensitive than that with the extract made from the snow crab meat. For this reason, we performed prick skin tests with all consenting participants who participated in a return appointment in 2003, using extracts from both snow crab meat (both cooked and raw) and snow crab cooking water.

The final test in the health assessment component was peak expiratory flow (PEF) monitoring conducted prior to and after return to work. All participating current workers were asked by the RRT if they would be willing to monitor their PEFs. Consenting workers were each provided with a Tru-zone peak flow meter or a Mini-Wright peak flow meter. The same type of peak flow

meter was used for all participants from a particular plant. They were also given two diary cards and two stamped, self-addressed envelopes. A training session, lasting 20–30 min was provided to those who consented to participate in PEF monitoring, along with a pamphlet with instructions on how to do Peak Flow Monitoring (PFM). A toll-free number was provided as a support for any questions relating to PFM and workers were encouraged to call regarding any questions relating to their PFM or other aspects of the OA project. No other support was provided. Interpretation of the PEF records was done by one of the investigators (AC) by visual analysis of the graphs showing PEF values over time.

Based on the combined, available results from medical questionnaires, prick skin tests with crab extract, specific RAST to snow crab, and PEF monitoring, AC arrived at five categories of diagnoses for both occupational allergy and snow crab OA: almost certain, highly probable, possible, unlikely, or negative. Table 2 shows the relationship between test results and diagnoses. Those with a diagnosis of “almost certain OA” had a medical history of symptoms of asthma during the season, improving after leaving work at the end of the season; a positive skin test or RAST to snow crab extracts; and positive PFM. Those with a diagnosis of “highly probable OA” had a positive medical history of symptoms of asthma during the season improving after leaving work, and one of the following: a positive skin test or RAST to snow crab extracts, but either no PFM data at work or negative/dubious/unreliable PFM; or positive PFM at work, but negative skin test or RAST. Those with a “possible” diagnosis had a positive medical history, negative RAST or skin test, and either no PFM data at work or negative/inadequate PFM. Those with a diagnosis of “unlikely or negative OA” had no history of asthma symptoms at work that improved after leaving work, could have had a negative or positive skin test or RAST, and had no PFM data or negative PFM results. Similar definitions were used for occupational allergy manifested by rhinitis, conjunctivitis, or rash.

2.2.1. Representativeness of the health assessment sample

Employers provided some data on years of employment up to 2001, gender, and date of birth for all current

and former workers on the original lists of current and former workers provided by the participating plants. This allowed us to compare the gender, years of seniority, and age composition of the health assessment sample to the overall current and former labor forces of those plants.

2.3. Allergen sampling component

Allergen sampling was done both with personal breathing zone (PBZ) samplers worn by consenting workers and with high-volume area samplers. Plants were divided into six or seven production areas associated with different aspects of the crab processing procedure. During the crab processing seasons of 2001 and 2002, air sampling pumps (at least one personal and, when possible, one area) were placed in each of these main areas in all four plants. Most PBZ air samples lasted the length of a full normal shift with a minimum of 4 h and a maximum of 8 h. Area pumps were located to ensure that they did not disrupt worker movements. For two plants, area pumps were calibrated prior to shipment to the researcher and upon return to the lab. For the other two, calibration was done at the beginning of the sampling and pumps were recalibrated after two consecutive 2-h samples.

The filters used in both PBZ and area samplers were polytetrafluoroethylene and were 99.9% efficient at 0.3 μm (Quan-Tec-Air, Inc., Rochester, MN). Both sample types were kept in dry storage at room temperature until processed for analysis. A preparation of snow crab cooking water (dry weight allergen designation of 45 mg/ml) was used as the allergen standard.

Sera containing snow-crab-specific IgE from sensitized workers were pooled and used to quantify airborne cooked and raw crab allergens in a competitive assay format. The limit of detection for the method was 100 ng/filter or 5 and 50 ng/m³ for area and PBZ samples, respectively. Each sample was assayed in duplicate and results were expressed as an arithmetic mean value (Reed et al., 1999; Yunginger and Swanson, 2000). Blank samples were included in the immunoassay analysis.

2.4. Cumulative exposures component

For this part of the study, allergen sampling results were used to divide the plant into zones with different average allergen levels. Areas, equipment, and job types that produced similar allergen levels were grouped into the same zone and each zone was allocated a single average exposure measure. While completing the medical and work history questionnaire for the worker health assessment, participants listed up to three main jobs that they had performed while working at the plant

and indicated how many seasons they had spent at each. This information was used to determine the areas of the plants in which the participants had worked and the period of time spent in each area over their careers. Given that this is a seasonal industry, and based on discussions with workers and owners about season length over the history of the various plants, we converted seasons to weeks to take into account changes over time and across plants in the length of seasons. Estimated cumulative exposures were calculated by multiplying the average exposure (geometric mean) in each zone by the number of weeks spent in that zone for each of the three jobs listed and summing the three subexposures to yield a final measure of exposure. The result is a value that encompasses both the length of time exposed and exposure levels for each participant in our health assessment component.

Discussions with management about the history of ventilation and processing in these plants suggested that the current situation with allergen levels is probably better than it was historically in all four plants. There had been a major improvement in ventilation and major changes in the production process in only one of the four plants over its history. The cumulative exposures analysis carried out for this paper assumed sampled allergen levels were typical of the plant history for all four plants. This means our exposure measure is likely to be conservative for these plants and that measured health effects at the cited exposure levels may be inflated.

2.5. Quality of life and socioeconomic impact component

Participants who had been diagnosed previously with asthma by their own physicians or who were suspected of having OA or occupational allergy based on medical history and skin test results during their appointment were asked to participate in taped, semistructured interviews about the quality of life and socioeconomic impacts of their asthma and allergy. Several of the questions on the interview schedule were derived from the literature on quality of life measurement (Jones et al., 1991; Juniper et al., 1992). Tapes were transcribed and analyzed using the QSR qualitative software program N6. The themes addressed were based on social psychological theory and on previous findings in related research (Juniper et al., 1993).

2.6. Statistical analysis

Chi-squared analyses were performed to test the association between gender and the variables used to assess knowledge, beliefs, and concerns, the prevalence of crab sensitization, and the prevalence of work-related symptoms. Independent *t*-tests were performed to determine whether the age distribution and the seniority

of participants and nonparticipants differed and whether a difference in allergen concentrations existed between male and female jobs in each of the four plants. Analyses of variance (ANOVA) were used to assess the differences in allergen levels across the four plants. Post hoc tests (LSD) determined specifically which plants differed. Statistical analyses were performed with SPSS software for Windows (SPSS Inc., Chicago, IL.).

3. Results

3.1. Knowledge, beliefs, and concerns component

A total of 196 individuals completed the knowledge, beliefs, and concerns questionnaire. Twenty of the respondents were in management positions in the crab plants, 18 of the respondents were health care professionals, and the remaining 158 respondents (92 females, 66 males) were crab processing workers. Overall, 60% of the worker respondents, 75% of the women compared to 39% of the men ($P < 0.001$), indicated that they associated “particular health problems with crab plant workers.” When asked to select the specific health problems they associated with crab plant workers men and women differed in their responses. Table 3 presents the percentage of respondents who associated particular symptoms with crab plant workers (male versus female). Women were significantly more likely than men to list shoulder pain, chest tightness, difficulty breathing, and cough.

Table 3
Proportion of all participants (male vs. female) who chose each listed symptom from a list in response to the “knowledge” survey question, “If you associate particular health problems with crab plant workers, what are those problems?”

Symptom	Males <i>n</i> (%), <i>N</i> = 66	Females <i>n</i> (%), <i>N</i> = 92	<i>P</i> value for male–female difference ^a
Back pain	22 (33)	43 (48)	.107
Shoulder pain	15 (23)	42 (47)	.003
Chest tightness	15 (23)	53 (58)	.001
Skin rash	10 (15)	32 (35)	.006
Cough	14 (21)	58 (63)	.001
Skin welts	4 (6)	6 (7)	.438
Difficulty breathing	12 (18)	51 (55)	.001
Sore throat	8 (12)	31 (34)	.001
Headache	14 (21)	37 (40)	.011
Swelling ankles	6 (9)	26 (28)	.002
Itchy eyes	13 (20)	40 (43)	.001
Hoarseness	8 (19)	35 (38)	.001
Bowel trouble	<5	5 (5)	.089
Water trouble	<5	7 (9)	.137
Minor cuts	7 (11)	12 (13)	.270
Poor sleep	12 (18)	26 (28)	.270

^a *P* value in χ^2 tests.

Men and women also responded differently when they were asked to indicate their agreement with some statements about the health risks associated with crab processing. When responding to the question, “In your opinion, the chances of getting sick while processing crab compared to processing cod are...,” more women (47%) than men (17%) said “much more” ($P = 0.001$). Table 4 presents the percentage of male versus female respondents who indicated agreement by responding “yes”, “no”, or “don’t know” to the listed belief statements about crab asthma. Gender differences in responses for the entire worker population were significant for 7 of the 14 belief statements. A gender analysis of the questionnaire results by job type revealed that significant gender differences in responses were less frequent among workers in the main processing area of the plant than in the whole worker population (Table 4). For respondents who worked in the main processing area (70 females, 17 males) doing jobs such as packing, sawing, cleaning, and cooking, gender differences in responses were significant for only three of the same belief statements. Unlike the entire worker population, male and female workers in the main processing area did not differ significantly in their responses to beliefs such as “people with crab asthma want to keep it secret”, “people who smoke are more likely to get crab asthma”, and “You can die from crab asthma.” The greater awareness among women that “Workers with crab asthma are eligible for worker’s compensation” was significant in the entire group but only of borderline significance in workers from the main processing area.

3.2. Worker health assessment component

Two hundred and fifteen processing workers (187 current/28 former, 95 male/120 female) participated in the worker health assessment. Female workers were significantly more likely to be sensitized to snow crab, as documented by positive skin test or RAST to snow crab allergens (29.4%, $n = 119$ versus 12.6%, $n = 95$; $P = 0.01$). Furthermore, women were significantly more likely than men to receive a diagnosis of almost certain/highly probable OA (27.5%, $n = 120$ versus 6.3%, $n = 95$; $P = 0.001$) and to receive a diagnosis of highly probable occupational rhinitis (20.8%, $n = 120$ versus 7.4%, $n = 95$; $P < 0.001$) occupational rash (15%, $n = 120$ versus 5.2%, $n = 95$; $P < 0.001$), or occupational conjunctivitis (16.7%, $n = 120$ versus 5.3%, $n = 95$; $P = 0.004$).

During the medical and work history interviews 106 of the 215 study participants were asked whether they had ever filed a worker’s compensation claim (this question was added after more than half of the participants had their appointment). Eighteen (17%) of 106 participants (9 male and 9 female) reported having filed a worker’s compensation claim and 14

Table 4

Proportion of all participants (male vs. female) who indicated yes, no, don't know in response to listed statements for the "beliefs and concerns" survey question, "Please answer the following to the best of your ability."

Belief	Response	Males <i>n</i> (%), <i>N</i> = 66	Females <i>n</i> (%), <i>N</i> = 92	<i>P</i> value ^a
Crab asthma is something parents can pass on to their children	Yes	38 (61)	54 (60)	.24
	No	10 (16)	23 (26)	
	Don't know	14 (23)	13 (14)	
People with crab asthma have an allergy to crab	Yes	< 5	< 5	.59
	No	47 (75)	71 (82)	
	Don't know	14 (22)	14 (16)	
Crab asthma is caused by eating crab	Yes	30 (48)	46 (51)	.83
	No	18 (29)	27 (30)	
	Don't know	15 (24)	18 (20)	
Crab asthma only occurs in people who work in crab plants	Yes	7 (11)	12 (13)	.54
	No	41 (65)	63 (70)	
	Don't know	15 (24)	15 (18)	
All people who have breathing problems who work in crab plants have crab asthma	Yes	9 (14)	6 (7)	.005*
	No	33 (52)	69 (78)	
	Don't know	21 (33)	14 (15)	
People with crab asthma want to keep it a secret	Yes	36 (57)	49 (55)	.001
	No	11 (18)	< 5	
	Don't know	16 (25)	38 (43)	
Crab fishermen can get crab asthma	Yes	12 (20)	19 (21)	.853
	No	25 (39)	39 (44)	
	Don't know	24 (39)	31 (35)	
Children of crab workers are more susceptible to asthma	Yes	13 (21)	24 (26)	.093
	No	22 (35)	42 (46)	
	Don't know	28 (44)	25 (28)	
Crab asthma goes away when you stop working at the crab plant	Yes	6 (9)	28 (30)	.001***
	No	18 (29)	31 (34)	
	Don't know	39 (62)	33 (36)	
People who smoke are more likely to get crab asthma	Yes	6 (10)	20 (22)	.017
	No	11 (17)	25 (28)	
	Don't know	46 (73)	46 (50)	
Asthma medication is addictive	Yes	6 (10)	4 (4)	.005**
	No	24 (40)	60 (67)	
	Don't know	30 (50)	26 (29)	
A blue puffer is all that is needed to manage crab asthma	Yes	17 (27)	23 (25)	.95
	No	10 (16)	16 (17)	
	Don't know	36 (57)	53 (58)	
Workers with crab asthma are eligible for worker's compensation	Yes	15 (24)	40 (44)	.016*
	No	9 (15)	5 (6)	
	Don't know	38 (61)	45 (50)	
You can die from crab asthma	Yes	6 (10)	6 (7)	.006
	No	43 (67)	79 (86)	
	Don't know	15 (23)	6 (7)	

* $P < 0.1$ in main processing workers; ** $P < 0.05$ in main processing workers; *** $P < 0.01$ in main processing workers.

^a P value in χ^2 test.

Table 5

Airborne crab allergen concentrations (mean, range) for each plant and for typical jobs carried out by males vs. females

PBZ overall					Male vs. female			
Plant	(N)	Mean (ng/m ³)	Range	P value ^a	Job	Mean (ng/m ³)	Range	P value ^b
1	13	75	22–150	< .001	Male-type ^c	79	47–129	.83
					Female-type	73	22–150	
2	34	504	27–2011	.04	Male-type	165	27–775	.001
					Female-type	689	202–2011	
3	33	115	34–244	< .001	Male-type	110	40–244	.83
					Female-type	117	34–235	
4	16	811	19–3188	—	Male-type	200	19–648	.017
					Female-type	1178	300–3188	

^aFrom ANOVA (LSD post hoc tests) comparing plant 4 to each other plant.^bFrom Student's *t* tests in comparisons between genders within each plant.^cSee Table 6 for details on type of job.

(77%) of those indicated that they had received some form of compensation. Most of the claims were for back or limb injuries and only one out of 18 claims was for OA from snow crab.

3.2.1. Representativeness of worker health assessment sample

Participation rates varied across plants and across tests. However, in all four plants somewhat less than half of the current and former workers we attempted to contact agreed to an appointment so participation rates for current and former workers from the four plants varied between 52% and 39% of those contacted, with an overall average of 47%.

The extent to which participants were representative of the larger labor force in the plant in terms of age, gender, and seniority varied from plant to plant. A χ^2 test revealed that the gender composition of the study population is significantly different from that of the overall labor force ($P = 0.0001$). The combined current and former worker labor forces for these plants were 59% male and 41% female. Females were overrepresented in the health assessment population relative to the plant labor forces (45% male versus 55% female). Complete age and seniority data for both the overall labor forces and the study population were only provided for two of the four plants. An analysis of the available data for these two plants showed that the mean age of the overall labor force in those two plants is 34.3 years, which is significantly different from the mean age of the participants in the study population (for those two plants), which was 38.5 years ($P = 0.02$). The average seniority of the workers in the two plant labor forces was 3.9 years. In the same two plants, the health assessment population's average seniority of 4.4 years was significantly different as well ($P = 0.008$). This comparison of the overall workforce to the study

population for these two plants suggests that overall, there is an overrepresentation of older, more senior, and female workers in the worker assessment population. Because the response rate was fairly low, senior and female workers were overrepresented among participants, and test results are incomplete (particularly for the PFM), our findings on gender-related differences in prevalence may be affected by selection bias.

3.3. Allergen sampling component—allergen levels and the gender division of labor

Over the course of several days at each plant in 2001 and 2002, a total of 211 air samples (96 PBZ and 115 area samples) were collected and later analyzed for allergen concentrations. The averages and ranges in allergen levels were calculated for the four plants and are shown in Table 5. Overall, allergen levels are highest in plants 2 and 4, where workers cook and manipulate cooked crab in particularly poorly ventilated areas. In contrast, overall allergen levels are lower in plants 1 and 3, where the procedure is to clean the crab before cooking it and to manipulate it less. Since these plants are also somewhat better ventilated it is difficult to separate the effects of raw processing on allergen levels from the ventilation effects. In all four plants, lower allergen levels are also associated with outside work, butchering and handling raw and frozen crab.

Work history data from the health assessment component were used to identify male and female jobs in the different plants. As indicated in Table 6, jobs typically done by women included those that are usually done in the main processing area, such as cleaning the crab and packing it. The jobs typically carried out by men include butchering and other jobs outside the main processing area and, in some cases, outside the plants. In plants 2 and 4, women's jobs were more likely than

Table 6
Distribution of workers in three main job types by gender

Job	Male (%)	Female (%)
Butcher	89	11
Packing and cleaning	34	66
Outside main processing area (i.e., butchering, loading, freezers)	72	28

men's to be associated with high allergen levels ($P < 0.001$ and $P = 0.017$, respectively, in Student's t -tests). Overall, allergen levels were statistically significantly higher in plant 4 than in all other plants ($P = 0.04$ when compared to plant 2 and $p < 0.001$ when compared to plants 3 and 1). Allergen levels in plant 2 were statistically significantly higher than in plant 3 ($P = 0.02$) and plant 1 ($P = 0.08$). There was no statistical difference in levels in plants 1 and 3, where overall allergen levels were lowest.

3.4. Cumulative exposures component

A gender analysis of "determinants of exposure" (Burstyn and Teshke, 1999) was carried out using data from the allergen sampling and work history data from the health assessment questionnaires. A comparison of the work histories for men and women health assessment participants indicated that, on average, women participants tended to have worked longer with crab (average of 5 years, minimum 1 month, maximum 24 years) than men (average of 3.5 years, minimum 1 month, maximum 10 years). Overall, median cumulative exposures differed significantly by sex for our study participants ($P = 0.0001$). Women ($CE = 4390.4 \text{ ng/m}^3 \times \text{weeks}$) had a much higher median cumulative exposure than men ($CE = 2553.1 \text{ ng/m}^3 \times \text{weeks}$).

3.5. Quality of life and socioeconomic impacts component

Of the original 215 participants in the health assessment component carried out in 2001 and 2002, 121 returned for their follow-up appointments in 2003. Thirty-eight of those 121 participants (30 female and 8 male), who had preliminary results suggesting that they had OA or allergy (dermatitis) to snow crab, agreed to participate in semistructured interviews related to the quality of life and socioeconomic impacts of asthma and allergy. Twenty-seven of these 38 received a final diagnosis of possible, highly probable, or almost certain OA and four had a final diagnosis of nonoccupational asthma. The remaining seven respondents were negative for asthma, OA to snow crab, and occupational allergy to snow crab.

Analysis of interview results for the 27 respondents who had final diagnoses of possible, highly probable, or almost certain OA produced several common themes suggesting significant life quality and socioeconomic impacts related to crab asthma and allergy to crab (Howse, 2003). All of these respondents reported using medication for their symptoms and most reported visiting the hospital or clinic to seek medical attention for their symptoms. Respondents from all four plants indicated that they were not pleased with the medical care they had received. They complained that the continuous turnover in doctors and nurses prevented them from establishing a relationship with a particular health care professional. Twenty-six of the 27 respondents indicated they were unwilling to consider leaving their jobs at the plant because they could not afford to give up the income and because there were no other job alternatives in their community. Twelve participants admitted to going to work despite feeling ill because they needed the hours in order to be eligible for Employment Insurance during the winter. All of the respondents described strategies they used to reduce or prevent symptoms at work, such as leaving their work station to get fresh air, moving to a different job or area within the plant, wearing masks or layers of clothes to keep the crab away from their faces and off their skin, and using medications such as inhaled salbutamol, inhaled steroids, and antihistamines during and between breaks. All respondents admitted they were apprehensive about filing claims for worker's compensation. Some reasons for this were because they or their family members had experienced difficulties with the system in the past or because they feared the compensation would be temporary or insufficient. Some also indicated that time off on worker's compensation would not count toward Employment Insurance (EI) eligibility.

4. Discussion

The results from our anonymous knowledge, beliefs, and concerns survey of worker participants in prestudy community meetings suggest that female workers are more aware than male workers of the symptoms associated with OA to snow crab. Overall, participating female workers are more likely than male workers to see crab processing as more dangerous than fish processing and are less concerned than male workers about the potential side effects of asthma medication. However, they appear to be less aware than male workers that asthma can, in exceptional circumstances, result in death. Gender differences in area worked (a proxy for exposure) do not seem to be the main factor underlying these different responses to the knowledge, beliefs, and concerns questionnaire, because significant differences persist for more than 40% of question items when we

compare male and female workers working in the main processing area. The absence of significant gender differences in some responses from workers in the main processing area was likely due to the small number of male workers in this sample. Both for the entire group of workers and for those in the main processing area, women were significantly more likely than men to believe that “All workers who have breathing problems who work in crab plants have crab asthma”, that “Crab asthma goes away when you stop working at the plant”, and that “Asthma medication is not addictive”. The knowledge, beliefs, and concerns questionnaires were completed in information meetings and did not include health-related questions, so we are unable to say whether self-reported gender-related health differences influenced responses from male and female workers working in the same areas of the plants.

Work and medical history questionnaire data from the health assessment component revealed a gender division of labor in the crab plants, with women working mostly in the main processing areas, which our allergen sampling results indicate have higher levels of allergens. They are more likely to do packing and cleaning jobs, while men tend to move around the plant more or work outside the main processing area, where average allergen levels are generally lower. Differences in allergen levels between areas dominated by female and male type jobs were significant in two of the four plants. The health assessment results need to be interpreted cautiously because of relatively low participation rates and evidence of selection bias in participants. However, they may reflect the effects of this division of labor in that more women have final diagnoses of almost certain, highly probable, or possible snow crab OA and allergy than men.

A gender analysis of cumulative exposures results suggests that women participants tended to have higher median cumulative exposures than male participants. In interpreting these results, it is interesting to note that a comparison of the gender composition of the labor forces in the four study plants shows that in the older plants and plants that do more manipulation of the crab there was a higher proportion of female workers in the plant labor forces. Thus, whereas in the oldest study plant (approximately 10 years) 48.8% of the labor force was composed of women, the proportion of female workers in the newer plants ranged between a low of 32.6% in a newer plant with little manipulation of the crab and a high of 43.8% in a relatively new plant with more manipulation. This suggests that over the past decade the proportion of men to women working in crab plants has increased, a pattern that may be due to the decline in employment alternatives to crab processing for men caused by the collapse of the groundfish stocks and reductions in fishing and groundfish processing employment in Newfoundland and Labrador. Across-

plant comparisons of the gender division of labor and exposures also suggest that in recent years, changes in processing have tended to be associated with increased automation and the tighter spatial integration of different job tasks. This means that as automation increases and processing changes, the gender division of labor and spatial segregation of women and men may be breaking down, potentially changing the relationship between gender and exposures.

In the case of OA and allergy to snow crab, it is unknown whether there is a threshold effect, with some concentrations of aerosolized snow crab allergen that do not sensitize. This research has inferred a relationship between gender and exposures, as well as cumulative exposures, by linking allergen sample results with work history data. Future research should collect PBZ samples from male and female workers in the same as well as different work areas, as well as carefully documenting job tasks and other factors that could vary on the basis of gender. More research is also needed on the relationship between different production processes, ventilation systems, and exposures and the relationship between particular exposures and the risk of developing occupational allergy and asthma to snow crab.

As with workers in other sectors (Shannon and Lowe, 2002), including those in work sectors dominated by vulnerable and often rural seasonal workers (Garcia 2003; Messing et al., 2003; Scherzer et al., 2005), this study provides strong evidence of serious underreporting and undercompensation. With one exception, participants in the quality of life and socioeconomic impact component of this study had not filed a claim with the Newfoundland and Labrador Workplace Health Safety and Compensation Commission (WHSCC) for OA or allergy despite experiencing symptoms that required medication. One reason for this may be that time off on workers' compensation cannot be counted toward EI eligibility. Since these were all seasonal workers and many of them were getting just enough hours to qualify for EI at the time of the study, they seem to have feared that any lost time at work could threaten their income during the off season. In these communities, because of the very short processing season, incomes are low and overall incomes from EI tend to exceed those from paid work. Workers who fail to qualify for EI in a particular year may require more than double the number of hours to qualify in future years. Another issue for workers appears to be access to health professionals knowledgeable about the complex WHSCC protocol of tests that must be completed in order for a claim to be successful. This protocol (introduced in 2000) was based on experience in Quebec, which has a very different and much more developed system for diagnosing and treating this type of occupational disease. Significantly, between 2000 and 2004, the

Newfoundland and Labrador WHSCC accepted only 10 claims for OA to shellfish (5 for medical aid and 5 for lost time). Twice as many claims were “denied or report only” with two main reasons for this: incomplete tests or failure of the worker to pursue the claim (E. Bartlett, personal communication, February 22, 2005). WHSCC has recently simplified the protocol to deal with this problem.

Participants in the socioeconomic and quality of life impacts part of this study were primarily female, making it impossible to explore the relationship between these impacts and gender. Overall responses indicate, however, that affected workers (male and female) will go to great lengths to minimize the risk of lost employment and income due to missed work and related EI benefits. This means that the greatest economic impacts will probably be evident among former workers who have been forced to give up their jobs at the plant and that older workers with homes and families, limited alternative work experience and formal education, and few employment options in these remote, rural communities are particularly likely to continue working after the onset of symptoms, increasing their risk of long-term respiratory problems continuing after they leave their jobs and eliminate exposures to snow crab.

Former workers were included in our original study design in order to enable us to identify the nature and extent of any “healthy worker effect” in snow crab processing and its gender dimensions. Unfortunately, we were able to contact relatively few of these workers, and not all of those we contacted agreed to participate (11 males, 21 females). Among these former workers, 7 females and no males received a diagnosis of almost certain/highly probable OA. Many other former workers appear to have been students and young people who worked at the plant temporarily while completing their schooling and have since left the community. Further research is needed to document more fully the nature and extent of any “healthy worker effect” associated with snow crab allergy and asthma in Newfoundland and Labrador, including its gender dimensions, as well as the gender dimensions of knowledge, beliefs, and concerns and of socioeconomic and quality of life impacts of allergy and asthma to snow crab among current and former workers. Here we asked only those with symptoms whether or not management had informed them of the risks associated with processing crab. Because of the risk of bias, this question ideally should be asked of all workers.

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