Snow crab allergy and asthma among Greenlandic workers – a pilot study

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Objectives. To study snow crab sensitization, occupational allergy and asthma in the snow crab industry in Greenland, as high rates have been found in Canada, but no reports have emerged from the same industry in Greenland.

Study design. Pilot survey.

Methods. Twenty workers (19 of Inuit and 1 of other origin) in a snow crab (Chionoecetes opilio) and Atlantic shrimp (Pandalus borealis) processing plant in Greenland were assessed with skin prick tests (SPTs) with common aeroallergens and specific allergens from snow crab and shrimp extracts, spirometry, blood sampling for total IgE and specific IgE determination. Eighteen workers contributed a questionnaire-based medical interview.

Results. Positive skin prick test reactions were common to snow crab (40%) and shrimp (20%). Specific IgE to snow crab were positive in 4 workers (21%). Two workers had elevated total IgE levels. Symptoms suggestive of asthma were common (45%). Work-related symptoms of skin rash, rhinitis, and/or conjunctivitis were reported by 50%, and symptoms from the lower airways by 39%. Combining history of work-related symptoms with results from specific SPTs and/or specific IgE determination suggested that 11 and 22% of workers suffered from probable and possible occupational asthma, respectively, whereas 22% had possible occupational dermatitis or rhinitis.

Conclusions. Greenlander Inuit do not appear to be protected against sensitization to snow crab or shrimp when occupationally exposed to these. This pilot study suggests that occupational allergy and asthma may be as common a problem in Greenlandic workers as in Canadian.

Keywords: occupational allergy; occupational asthma; organic dusts; sensitizers; crustacea; Anisakis

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positive skin prick tests (SPTs) and specific IgE to snow crab cooking water, raw and cooked meat frequently, but not always, being seen in symptomatic workers. The lack of reports of OA in Greenlandic snow crab workers could suggest that Greenlanders, of which most are of Inuit origin, are protected against sensitization and allergic disease. This would be consistent with a lower prevalence of atopy observed in Greenlandic children (7).

We hypothesized that the lack of reports of OA or OA in the snow crab industry in GL reflected either a low prevalence of sensitization to snow crab, or a lack of awareness among employees, employers, and health professionals that seafood processing may cause allergy or asthma. We therefore conducted a pilot study in a snow crab processing facility in GL to obtain preliminary data on the rates of work-related allergy and asthma in GL snow crab processing workers. Our objective was to conduct the first study of this kind among Greenlandic seafood workers and to elucidate if protection against allergic sensitization was a likely explanation for lacking reports of occupational allergies in Greenland.

Materials and methods

The Directory of Fisheries under the GL government and GL Institute of Natural Resources, 4 facilities which processed snow crab in the 2006 season were identified. The largest of these facilities with 20 part-time and full-time employees was contacted, and they agreed to participate. All current seasonal and full-time workers with regular contact with snow crab irrespective of their job position, as well as a few former workers, were invited to participate. The investigation took place in September 2007 towards the end of the harvesting season. The study was approved by the Ethics Committee for Health Research in GL and by the Ethics Committee of Hôpital du Sacré-Cœur de Montréal. All participants gave informed consent before the study.

Questionnaire

A questionnaire on the past and present job history and medical history was delivered in Danish or Greenlandic depending on the workers’ preference. It was based on a questionnaire derived from questionnaires for asthma previously used in an earlier study (8). It was translated into Greenlandic by a professional translator. The workers filled in the questionnaires themselves with a local translator present who, after an instruction by the investigators and with access to the investigators present on site, helped in case of difficulties with understanding or responding. Information was obtained on symptoms of upper and lower respiratory symptoms in general and on exposure to non-allergenic (i.e. on exercise, on strenuous work, on exposure to cold air, with flu or cold, on exposure to strong odours) or allergic triggers (cat, dogs, house dust); personal & family history of asthma; family history of atopy; smoking habits; and work-related symptoms of skin rash, rhinitis, and conjunctivitis (suggestive of allergy), and of wheezing, cough, and/or shortness of breath (suggestive of asthma) that improved at the end of the snow crab season.

Skin prick tests and IgE assays

Extracts at a final concentration of 10 mg/ml (in 50% glycerol) for SPTs and specific IgE antibody determination were prepared from snow crab cooked meat, and snow crab cooking water obtained from a Newfoundland & Labrador plant according to the methods described previously (9), and from snow crab raw meat blended in PBS and similarly processed. SPTs were performed on the ventral aspect of the forearm with snow crab extracts, Atlantic shrimp (Pandalus borealis) and cod (Gadus morhua) extracts (Soluprick, ALK-Abellô, Hørsholm, Denmark) and with the most common arctic aeroallergens grass (Phleum pratense), mugwort (Artemisia vulgaris), birch (Betula verrucosa), dog (Canis domesticus), cat (Felis domesticus), and the dustmites D. farinae and D. pteronyssinus (7). Reactions were read after 15 min and considered positive if the largest wheal diameter was ≥3 mm with a positive reaction to histamine phosphate (1 mg/ml) and negative to saline. Atopy was defined as a positive reaction to at least one common aeroallergen.

Venous blood, collected in EDTA coated tubes, was kept on ice until centrifugation, after which the sera were refrigerated and stored at −20°C until arrival in Montréal (Canada) where they were frozen at −80°C until analysis. A quantitative enzyme-linked immunosorbent assay-based test kit for the detection of human total IgE in subjects’ sera was used according to the manufacturer’s instructions (ICL, Inc., Newberg, OR, USA). Sera were diluted in 1:2 or 1:10, and 2 samples in 1:100. Because hyperlipidemic serum may interfere with antibody binding in immunoassay procedures, sera with evidence of hyperlipidemia were filtered through a 0.22 µm cellulose acetate membrane. The range of the standard curve is 3.9–250 ng/ml total IgE. This kit used the IgE World Health Organization (WHO) IgE 75/502 calibrator; therefore, IgE expressed in ng/ml was converted to kU/L (1 IU/ml = 2.4 ng/ml).

Sera were also assayed for IgE-specific antibodies to snow crab by the Radioallergosorbent test (RAST). Cyanogen bromide-activated paper discs were coupled with aqueous corn extract (preparation described in subsequent section) at 100 μg/disc. One hundred microlitres of serum was added to duplicate discs, incubated overnight on a rotator at 24°C, and washed 3 times with 0.9% saline. One hundred microlitres of 125I-labelled equine anti-human IgE diluted to contain 15,000 cpm (Sanoﬁ Diagnostics Pasteur, Chaska, MN, USA) was added to each tube, discs incubated overnight, and washed as described. Bound 125I-IgE was counted in a Beckman
The best FEV1 and FVC were taken from the stored were calculated using the back extrapolation technique. Symptom at work improving away from work, but no possible OA after starting work with snow crab and specific sensitization to snow crab extract, or a history of physician diagnosed asthma at work improving at the end of the snow crab season or away from work, and sensitization to snow crab defined by positive SPT or specific IgE test to ≥1 snow crab extract; the same categories as for OA were defined: probable, possible, negative, and probably negative.

**Walk-through survey and description of processes and machinery used**
A walk-through survey of the snow crab processing facility was performed by JHB, DG, TS and AC together with the management of the plant. Snow crabs were delivered in ice-filled boxes directly on the wharf of the factory from 3 local fishing vessels which only harvested snow crab at a distance of approximately 1 day's travel, assuring delivery of live crab. All snow crabs were processed within the day of arrival. Butchering, brushing, and scraping of barnacles took place manually on the ground floor. Further processing took place after automatic transport to one large room on the first floor. Cooking of the snow crab was the first process in that room, and further processing (cleaning, weighing, sorting, packaging, and freezing) was done manually once the snow crab had been cooked. Good exhaust ventilation was in function over the partly enclosed cooking area. Otherwise, only general room ventilation was observed. Machinery was Canadian and processing did not appear to differ from common methods in Canada known to the investigators.

**Statistical analysis**
As this was a pilot study, only descriptive statistics are presented: means and standard deviations for continuous variables and frequencies and percentages for categorical variables. The statistics were performed using SPSS 17.0 for Windows (Statistical Package for Social Sciences, Chicago, IL, USA).

**Results**
Nineteen of the 20 eligible current workers on the facility participated. Two were employees from the administration who were regularly in contact with the snow crab. In addition 1 former worker participated. The demographics, job history, and baseline clinical data of the participants are shown in Table I. All workers answering the questionnaire were current or former workers.

Eighteen workers responded to the questionnaire. Seven reported any phlegm (39%) and 2 reported phlegm lasting more than 3 months a year (11%). Asthma diagnosed by a physician was reported by 3 employees (17%). In all cases the asthma had been diagnosed after start of work in the snow crab factory. Of the 20 workers, 4 (20%) had a positive reaction to 1 or more of the common inhaled allergens and were thus considered atopic.

The mean FEV1/FVC ratio was 81.0% corresponding to 99.5% of the predicted (Table I). Two employees (44 and 47 years of age) had a low FEV1/FVC ratio and symptoms suggestive of mild COPD.
The observed rate of sensitization to shrimp (20%) among these workers was similar to previous findings (14). Work-related airway symptoms were common among the workers of this study. Although the prevalence of smoking was high (83%), only 11% of the workers reported typical symptoms suggestive of chronic bronchitis. Despite the consistent use of a skilled local interpreter, language issues may have caused bias in the reporting of 1 or more symptoms among the studied workers. Nevertheless, an important fraction of the airway symptoms could be due to work-related airway disease.

The means of FEV₁ and FVC calculated as percent-predicted were high despite the high prevalence of smoking and airway symptoms. This could be signalling a healthy worker’s selection. However, young Greenlander Inuit have been observed to have greater spirometry values for the same age and height than do ethnic Danes (15). Unfortunately no exact predictive equations specific to Inuit, allowing for correction, existed.

**Table 1.** Demographics, atopy, clinical and functional characteristics and work history of snow crab workers in a Greenland processing plant

| Characteristic                                      | n (%) |
|-----------------------------------------------------|-------|
| Participants, n                                     | 20    |
| Age (years), mean ± SD (range)                      | 35.9 ± 11.4 (18 - 56) |
| Gender (M/F), n                                     | 6/14  |
| Ethnic group (Inuit/other), n                       | 19/1  |
| Smoking (S/Ex-S/NS), n                              | 15/3/0 |
| Education (school/high school/technical), n         | 4/11/3 |
| Atopy, n (%)                                        | 4 (20) |
| Symptoms suggestive of asthma n (%)                 | 9 (50) |
| Physician-diagnosed asthma, n (%)                  | 3 (17) |
| FEV₁, % predicted, mean ± SD (range)               | 100% ± 12.3 (78 - 122%) |
| FEV₁/FVC, mean ± SD (range)                        | 81.0% ± 6.9 (68.4 - 91.1%) |
| Duration of work with crab (years), mean ± SD       | 3.0 ± 3.0 |
| Duration of work in current plant (years), mean ± SD| 2.3 ± 1.7 |
| Exposure to shrimp, n (%)                           | 14 (77.8) |

*Defined by positive skin prick test to at least one common inhaled allergen; †Two of the following: cough, wheeze, chest tightness or shortness of breath on exposure to 2 or more triggers; ‡Data available for 18 participants.

The mean length of work in the processing plant was 2.3 years (± 1.7). One worker indicated change of job type 3 months prior to the survey moving to snow crab processing due to health problems related to snow crab processing, having difficulty to support the fog near the boilers in the production area where he had been working for almost 4 years. Fourteen workers reported that occasionally they were also processing shrimp.

Data on atopy, SPT responses to shrimp and snow crab extracts, specific IgE to snow crab and Anisakis, total IgE, work-related symptoms, physician diagnosis of asthma and likelihood of OA and OAI are given in Table II.

A total of 8 employees (40%) were SPT positive to snow crab. Four employees (20%) were positive to shrimp, and 2 (10%) to cod (not shown); all of these employees had positive snow crab SPT tests. Three of the 8 employees with a positive SPT to snow crab were atopic. Four employees (21%) had positive IgE to at least one snow crab extract, and these employees also had positive SPT reaction to snow crab. Total IgE varied between 7 and 2,503 kU/L with a mean value of 227 kU/L and a median value of 29 kU/L. Positive, specific IgE responses to Anisakis (≥ 0.35 kU/L) were found in 5 employees (26%). The 2 highest levels were seen in the employees with the highest total IgE levels. In one employee (no. 14, Table II) these elevated IgE levels were not associated with reported symptoms suggestive of OA or OAI. No clinical data was available for the other employee (no. 19, Table II). In the remaining 3 employees with positive specific IgE to Anisakis, OAI or OA was suspected. A total of 9 employees (50%) reported at least one symptom of allergy in their current job: 8 (44%) reported runny or stuffy nose at work, 4 (22%) reported ocular symptoms, and 4 (22%) skin rash; 6 workers (33%) reported at least 2 of the above symptoms among which 3 reported improvement when away from work. Seven workers (39%) reported at least one chest symptom at work that improved away from work in 5 of them. Probable OA was seen in 2 (11.1%) workers and possible OA in 4 (22%), while 4 (22%) workers had a likely diagnosis of possible OAI according to the algorithm described above.

One of the 3 employees with a physician’s diagnosis of asthma was SPT positive to snow crab, but reported no work-related symptoms. The other 2 were SPT negative to snow crab but reported work-related upper and lower respiratory symptoms.

**Discussion**

In this pilot study, the rate of specific sensitization to snow crab was surprisingly high (40%) among the 20 employees. The combination of a high rate of specific sensitization and of work-related airway symptoms more evocative of allergy and asthma than of chronic bronchitis suggests that occupational allergy and asthma does occur in Greenlandic snow crab workers and does not preclude that the prevalence may be in the same range as found in Canadian studies (4,5). The study included, however, too few workers to justify stronger conclusions on the prevalence of occupational allergy and asthma in the population of snow crab processors.
| Crab worker no. | Atopy | SPT Shrimp (mm) | RAST Shrimp | SPT Raw crab (mm) | RAST Raw crab | SPT Cooked crab (mm) | RAST Cooked crab | SPT Crab water (mm) | RAST Crab water | Anisakis IgE (kU/L) | Total IgE (kU/L) | Work-related symptoms<sup>4</sup> | Physician diagnosis of asthma | Lower airways | Nasal and/or ocular | Likelihood of OA | Likelihood of OAI |
|----------------|-------|----------------|-------------|------------------|---------------|----------------------|------------------|-------------------|----------------|----------------|----------------|-------------------------------|-------------------------------|---------------|-----------------|---------------|-----------------|
| 1              | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.11              | 84             | No             | Yes            | No                            | Possible                        | No            | No               | Yes           | No              |
| 2              | Yes   | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.35              | 15             | Yes            | No             | Yes                           | Possible                        | No            | No               | Yes           | No              |
| 3              | No    | 0              | Neg.        | 2                | Neg.          | 4                    | Neg.             | 0.03              | 75             | No             | No             | No                            | Possible                        | No            | No               | Yes           | No              |
| 4              | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 2.1               | 14             | Yes            | Yes            | Yes                           | Possible                        | No            | No               | Yes           | No              |
| 5              | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.00              | 93             | Yes            | Yes            | Yes                           | Possible                        | No            | No               | Yes           | No              |
| 6              | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.00              | 8              | No             | Yes            | No                            | Possible                        | No            | No               | Yes           | No              |
| 7              | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.08              | 29             | No             | Yes            | No                            | Possible                        | No            | No               | Yes           | No              |
| 8              | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.01              | 26             | Yes<sup>e</sup> | No             | No                            | Possible                        | No            | No               | Yes           | No              |
| 9              | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.00              | 15             | Yes            | No             | No                            | Possible                        | No            | No               | Yes           | No              |
| 10             | No    | 3              | Neg.        | 3                | (1.6%)        | 0                    | Neg.             | 0.06              | 191            | No             | No             | No                            | No                            | No            | No               | No           | No              |
| 11             | Yes   | 0              | 2.4%        | 4                | 4.7%          | 3                    | 4.4%             | 0.02              | 118            | No             | No             | No                            | No                            | No            | No               | No           | No              |
| 12<sup>f</sup> | Yes   | 3              | –            | 0                | –             | 3                    | –                | –                 | –              | No             | No             | No                            | No                            | No            | No               | No           | No              |
| 13             | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.09              | 7              | No             | No             | No                            | No                            | No            | No               | No           | No              |
| 14             | No    | 3              | 4            | (1.28%)         | 0             | 2.36%                | 0                | >100              | 2,503          | No             | No             | No                            | No                            | No            | No               | No           | No              |
| 15             | No    | 0              | 2.5%        | 3                | 2.1%          | 2                    | 2.35%            | 0.48              | 20             | Yes<sup>e</sup> | No             | No                            | Probable                        | No            | No               | No           | No              |
| 16             | No    | 2              | 7.8%        | 3                | 12.5%         | 8                    | Neg.             | 0.08              | 166            | No             | No             | Yes                           | Probable                        | No            | No               | Yes          | No              |
| 17             | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.23              | 18             | No             | No             | No                            | No                            | No            | No               | No           | No              |
| 18             | No    | 0              | Neg.        | 0                | (0.62%)       | 0                    | (0.17%)          | 0.00              | 38             | No             | No             | No                            | No                            | No            | No               | No           | No              |
| 19<sup>g</sup> | Yes   | 3              | Neg.        | 0                | (0.47%)       | 2                    | (0.23%)          | 74.9              | 859            | –              | –              | –                            | –                              | –             | –                | –            | –               |
| 20<sup>g</sup> | No    | 0              | Neg.        | 0                | Neg.          | 0                    | Neg.             | 0.00              | 28             | –              | –              | –                            | –                              | –             | –                | –            | –               |

<sup>a</sup>Skin prick test, positive if wheal diameter ≥3 mm;<sup>b</sup>Radioallergosorbent test (RAST) in crab workers’ sera;<sup>c</sup>Result of RAST expressed as percentage binding of [125I]labelled anti-IgE, negative being <2%;<sup>d</sup>At least one symptom at work that goes away at the end of the working season;<sup>e</sup>Subject had work-related lower respiratory symptoms improving over weekends or holidays but did not know if they went away after working season;<sup>f</sup>Serum sample not available;<sup>g</sup>Questionnaire data not available.
A possible or probable diagnosis of OA was seen in 33% (6/18) of employees, while a possible diagnosis of OAI (rhinitis, conjunctivitis, or dermatitis) was seen in 22% (4/18) of workers. Three of these employees had been diagnosed with asthma by a physician after the start of their current job. Due to lack of serial measurements of peak expiratory flows and of non-specific bronchial responsiveness or of specific inhalation challenges, the diagnosis of asthma (and OA) could not be confirmed. During discussions with the chief physician of the local hospital, with the director of the plant, and the employees themselves we received information that complaints about respiratory problems and suspicions of allergic reactions among workers at the factory were not uncommon. Anecdotal reports of workers leaving the factory due to respiratory complaints could not be formally investigated, and we did not obtain useful data on the turnover of workers.

The strength of the study was the high participation rate both among full term and seasonally employed workers. A professional translator with access to the investigators assured a high response rate and a standardized response to the questionnaire. Major weaknesses were the small population size and limited time not allowing for peak flow monitoring.

No clear association could be observed between the number of years worked with snow crab or with specific job tasks in the current job and the risk of symptoms from either nose, eyes, skin, or lower airways. However, longer histories of seafood exposure were reported by the workers with positive SPT to snow crab or shrimp (mean 4.0 years) compared with those without positive reactions (2.3 years).

Two workers (nos. 14 and 19) with specific IgE to snow crab had high total IgE levels. Even though these 2 workers had high specific IgE to Anisakis, it is unlikely that this reflects parasitic infestation alone. Indeed while Anisakis simplex is very common in seafood and whitefish in GL, a recent study suggested that the prevalence of Anisakis infestation among children in GL is low (20%) in the Greenlandic snow crab workers studied although the rate of atopy observed is indeed relatively low (20%) in the Greenlandic snow crab workers studied. Whether these gene variants in Greenlanders play a role in determining responses to environmental conditions such as cold and humid air.

The lack of previous reports of OA in Greenland’s snow crab workers had suggested that they were protected against sensitization and allergic disease. This is consistent with a lower prevalence of atopy, a known risk factor for sensitization to snow crab (4,5), observed in Greenlandic children (9). This is supported by studies showing that polymorphisms in the IL4RA gene, associated with lower risks of atopy, are common in Greenlander Inuit (20). In a recent study, gene–environment interactions in the SCGB1A1 and ADRB2 genes among Inuit were observed, indicating that some variants of these genes were associated with decreased risk of rhinitis or asthma among Inuit living in GL, but with increased risk among Inuit living in Denmark (21). Whether these gene variants in Greenlanders play a role in determining responses to the occupational snow crab exposure that differ from other populations remains purely speculative. However, although the rate of atopy observed is indeed relatively low (20%) in the Greenlandic snow crab workers studied here, our data suggest that Inuit are not protected against sensitization to snow crab and are at risk of developing occupational allergy and asthma. The association between atopy and sensitization to snow crab was not assessed formally given the small number of subjects.
Underreporting is likely to contribute to the lack of reports of OA1 and OA from the Greenlandic snow crab and shrimp processing industry. Possible reasons for underreporting include on one hand a lack of awareness of occupational allergy and asthma among workers, employers, and physicians, and on the other hand better access to alternative jobs in the Greenlandic community as opposed to the Canadian communities previously studied, resulting in symptomatic workers leaving the industry earlier and resulting in a possible healthy worker effect. As suggested by Jeebhay et al. (22) much of the world’s seafood is processed in small coastal communities with less than average access to occupational surveillance, health care and alternative jobs. Increased awareness of the potential hazards from seafood processing in these communities is likely to be needed in order to get a truer picture of the incidence and prevalence of OA and OA1.

In conclusion this pilot study suggests that Greenlander Inuit seafood processors have a high rate of sensitization to snow crab and shrimp, and do not appear to be protected against OA and allergy. We recommend that employees in the seafood industry in GL with airway symptoms should contact their physician in order to exclude OA or allergy. A survey in a larger population is needed to assess with confidence the prevalence of OA1 and OAl.

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