Respiratory Symptoms and Exposure to Wood Smoke in an Isolated Northern Community

Michael Guggisberg[1]
Patrick A. Hessel, PhD[2]
Dennis Michaelchuk, MA[2]
Iqbal Ahmed, MD, MSc, MPH[3]

ABSTRACT

Background: Wood smoke has been associated with respiratory symptoms. This study examined the prevalence of respiratory symptoms and health effects of wood smoke exposures (from home heating, curing meat, and tanning hides) among residents of Deline, Northwest Territories (NWT).

Methods: A survey was conducted of all residents. Relationships between wood smoke and respiratory symptoms were examined.

Results: The response rate was 70.2% (n=402). 71% of people at least 18 years old were current smokers. Prevalence of symptoms was higher for women (odds ratios (ORs) 1.3-3.1). Women who smoked were more likely to be exposed to indoor smoke from curing and tanning. ORs for respiratory symptoms were higher for females, increased with age, and were strongly affected by smoking. Among those at least 18 years old, phlegm on winter mornings (6.5 (95% CI: 2.3-18.1)), dyspnoea (5.1 (95% CI: 1.9-13.2)), and watery or itchy eyes (3.6 (95% CI: 1.4-9.0)) were significantly related to self-reported outdoor wood smoke and smoke curing. Home heating was marginally associated with wheeze. No significant associations were found for males.

Conclusions: Women engaged in curing/tanning demonstrated increased prevalence of respiratory symptoms. The cultural importance of these activities precludes abandoning them. Smoking cessation, limiting wood smoke exposure times, and process modifications in curing and tanning could reduce risk of adverse health effects.

La traduction du résumé se trouve à la fin de l'article.

1. Department of Environmental Sciences, Swiss Federal Institute of Technology, Zurich, Switzerland
2. Department of Public Health Sciences, University of Alberta, Edmonton, Alberta
3. Richmond Health Sciences Centre, Richmond, British Columbia
Correspondence: Dr. Patrick Hessel, Exponent, 2 North Riverside Plaza, Suite 1400, Chicago, Illinois, USA 60606 Tel: 312-627-2004, Fax: 312-627-1617, E-mail: phessel@exponent.com
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The health of Aboriginal people in North America is poorer than that of the non-Aboriginal population.[1-6] Although life expectancy and functional health status have been gradually improving over the last decade,[7] life expectancy for males and females in the Northwest Territories (NWT) was, respectively, four and three years shorter than for their counterparts across Canada.

Respiratory health is particularly compromised among the Aboriginal population. Age-standardized mortality for respiratory conditions in the NWT was 34% higher than the rate for Canada. Respiratory diseases accounted for over 10% of all inpatient hospital visits in the NWT. This is consistent with data for US Indians.[5] Approximately one quarter of visits to community clinics in the NWT are for respiratory conditions.[7] A study in an Aboriginal community in northwestern Ontario found that respiratory diseases accounted for almost 50% of all episodes of illness.[8] Emergency department visits for both asthma and chronic obstructive pulmonary disease were found to be 2.1 and 1.6 times more common, respectively, among Aboriginal compared to non-Aboriginal residents of Alberta.[9] Among those visiting the emergency department for either of these conditions, Aboriginal patients were significantly less likely than non-Aboriginal patients to be seen by a specialist or to undergo spirometry.

Some risk factors for respiratory diseases are more common among Aboriginal populations than among their non-Aboriginal counterparts. Aboriginal people generally live in poorer housing and this is particularly common in smaller, isolated communities. Over 50% of Aboriginal people in the NWT over age 15 are current smokers, compared to 29% for Canada.[7] In the US, it was reported in 1990 that houses on reserves were more likely to be heated by wood (34%) than all US houses (4%).[10]

Larson and Koenig showed a consistent association between exposure to wood smoke and increased respiratory symptoms and lower respiratory tract infections, and decreased pulmonary function among children at concentrations observed in homes in developed countries.[11] Based on 13 studies, Smith et al. calculated odds ratios (ORs) between 2.2 and 7.0 for acute lower respiratory tract infections in children exposed to indoor biomass smoke in developing countries.[12]

The importance of respiratory disease in Aboriginal populations throughout North America, the growing evidence of an association between wood smoke and respiratory problems, and a high exposure prevalence in remote, northern communities prompted the present study. The objectives were to document the prevalence of respiratory symptoms in Deline, NWT, and to examine the role of exposure to wood smoke as a potential risk factor.

MATERIALS AND METHODS

Study population

The study community, Deline (formerly Fort Franklin), is located 544 km northwest of Yellowknife. The average temperature in January is -24.0°C. The heating season lasts from September until May. Access is limited to air service and a winter road. In 1994 the population was 573, of whom 90% were Aboriginal. Lifestyles ranged from traditional to modern.

The study was prompted by concerns of the local physician who felt there was a high prevalence of respiratory problems, especially among older women. Through the physician and staff at the nursing station, contact was made with the Band leadership. The nurses were also helpful in identifying Band members with experience in interviewing. In cooperation with the leaders of the community, data were collected from April through November 1994. Meetings were held to inform residents about the study and procedures for participation. Ethics approval was obtained from the Ethics Review Board at the University of Alberta.

Health status assessment

The questionnaire was based on a standardized instrument.[13] Questions on housing were adapted to the local situation and questions on exposure to wood smoke were added. The questionnaire was translated into North Slavey and back-translated. Trained community members interviewed study participants in the language they preferred. Most interviews were conducted in the homes (84%), 14% at the health centre, and the rest by phone or at work. The questionnaires for those <18 years old were answered either personally or by parents or other family members. Questionnaires were completed by 70.2% of the population (n=402). Non-Aboriginal people (10.0%) were eliminated from the analysis. Non-respondents had either moved or were away attending school (7.9%), refused to participate (5.9%), or were absent at the time of the interview or unable to be located (6.0%).

Two sets of variables for indoor and outdoor wood smoke exposure were used. Participants were asked whether, in the last 12 months, they had been regularly exposed to wood smoke indoors and outdoors (separately). These variables were denoted in the tables as "self-reported" exposure. The second set was based on the assumption that living in a house heated by wood and doing smoke curing reflected exposure to wood smoke. People heating with a mixture of fuels were excluded from these analyses as there was no distinction between primary and secondary fuel.

In this region, small huts called tipis are used to smoke cure meat and tan hides. Smoke is produced by a smoldering fire and a high concentration of smoke is required. Individuals were considered exposed to outdoor wood smoke in tipis if they stated that they smoked meat or fish, or if they tanned hides. Indoor levels of particulate matter less than 10 microns (PM_{10}) ranged from 0.12 to 0.53 mg/m^3 without significant differences between houses heated with wood or oil. Exposures of people working in tipis averaged 2.29 mg/m^3. For comparison, the occupational standard for PM_{10} in the US is 5 mg/m^3. The Canadian ambient air quality standard is 0.1 mg/m^3.

TABLE I

Distribution of Respondents by Sex, Age, and Tobacco Exposure

	Age Category <18 yrs n (%)	Age Category ≥18 yrs n (%)	All Participants n (%)
Sex			
Female	86 (49.7)	126 (55.0)	212 (52.7)
Male	87 (50.3)	103 (45.0)	190 (47.3)
Total	173 (100)	229 (100)	402 (100)
Age group (years)			
≤9	102 (59.0)	0 (0)	102 (25.4)
10-24	71 (41.0)	62 (27.1)	133 (33.1)
25-49	0 (0)	121 (52.8)	121 (30.1)
≥50	0 (0)	46 (20.1)	46 (11.4)
Total	173 (100)	229 (100)	402 (100)
Smoking habit			
Non-smoker	168 (97.1)	47 (20.5)	215 (53.5)
Ex-smoker	0 (0)	19 (8.3)	19 (4.7)
Current smoker	5 (2.9)	163 (71.2)	168 (41.8)
Total	173 (100)	229 (100)	402 (100)
Pack-years† (mean(SD))	1.1 (1.1)	17.1 (20.3)	16.7 (20.2)
ETS‡			
No exposure	37 (21.5)	45 (20.0)	82 (20.7)
≤4 hrs per day	60 (34.9)	89 (39.6)	149 (37.5)
5-8 hrs per day	60 (34.9)	55 (24.4)	115 (29.0)
>8 hrs per day	15 (8.7)	36 (16.0)	51 (12.8)
Total	172 (100)	225 (100)*	397 (100)

† Includes ex-smokers and current smokers
‡ Environmental tobacco smoke
* p<0.05

TABLE II

Prevalence of Respiratory Symptoms by Age and Sex

Symptom	<18 years old Female n=85 n (%)	<18 years old Male n=87 n (%)	≥18 years old Female n=127 n (%)	≥18 years old Male n=103 n (%)	All Participants n=402 n (%)
Wheezing in the last 12 months	5 (5.8)	7 (8.0)	45 (35.7)	22 (21.4)*	79 (19.7)
Wheezing in the absence of a cold	4 (4.7)	5 (5.7)	29 (23.0)	9 (8.9)*	47 (11.7)
Tightness in chest when waking up	1 (1.2)	1 (1.1)	33 (26.2)	20 (19.4)	55 (13.7)
Cough on winter mornings	7 (8.1)	8 (9.2)	35 (27.8)	23 (22.3)	73 (18.2)
Phlegm on winter mornings	5 (5.8)	8 (9.2)	44 (34.9)	27 (26.2)	84 (20.9)
Dyspnoea on exertion	4 (4.3)	6 (6.9)	52 (41.3)	24 (23.3)*	86 (21.4)
Watery or itchy eyes	9 (10.5)	7 (8.0)	38 (30.2)	17 (16.5)*	71 (17.7)

* p<0.05, comparing males and females

TABLE III

Odds Ratios (OR)† and 95% Confidence Intervals (CI) for Associations Between Respiratory Symptoms and Self-reported Indoor and Outdoor Exposures for Those ≥18 Years Old

	Female		Male		All Participants	
Symptom	Indoor OR (CI)	Outdoor OR (CI)	Indoor OR (CI)	Outdoor OR (CI)	Indoor OR (CI)	Outdoor OR (CI)
Wheezing in the last 12 months	1.5 (0.5-4.6)	1.1 (0.5-2.7)	1.0 (0.2-4.0)	2.3 (0.7-7.4)	1.3 (0.6-3.1)	1.5 (0.8-3.0)
Wheezing in the absence of a cold	3.1 (1.0-10.3)	1.2 (0.4-3.3)	‡	‡	1.6 (0.6-4.4)	1.3 (0.6-3.0)
Tightness in chest when waking up	0.4 (0.1-1.5)	1.7 (0.7-4.3)	2.9 (0.8-10.6)	1.8 (0.6-5.5)	0.9 (0.4-2.2)	1.6 (0.8-3.3)
Cough on winter mornings	1.8 (0.6-5.9)	1.3 (0.5-3.3)	0.6 (0.1-2.7)	1.1 (0.4-3.6)	1.2 (0.5-3.0)	1.3 (0.6-2.6)
Phlegm on winter mornings	1.5 (0.5-4.7)	2.2 (0.9-5.4)	1.3 (0.3-4.7)	1.0 (0.3-2.8)	1.1 (0.5-2.6)	1.4 (0.7-2.6)
Dyspnoea on exertion	1.0 (0.3-3.3)	7.4 (2.7-20.2)**	0.5 (0.1-2.2)	2.3 (0.8-6.9)	0.8 (0.3-1.8)	4.2 (2.1-8.5)**
Watery or itchy eyes	0.6 (0.2-1.9)	3.6 (1.4-9.0)*	1.3 (0.3-5.8)	2.1 (0.6-7.2)	0.9 (0.3-2.2)	3.1 (1.5-6.5)*

† Controlled for age, smoking category, and exposure to ETS
‡ Not enough cases available
* p<0.05, **p<0.001

TABLE IV

Odds Ratios (OR)† and 95% Confidence Intervals (CI) for Associations Between Respiratory Symptoms and Exposure to Wood-fueled Furnaces and Smoke Curing for Those ≥18 Years Old

	Female		Male		All Participants	
Symptom	Wood-fueled Furnaces OR (CI)	Smoke Curing OR (CI)	Wood-fueled Furnaces OR (CI)	Smoke Curing OR (CI)	Wood-fueled Furnaces OR (CI)	Smoke Curing OR (CI)
Wheezing in the last 12 months	0.9 (0.2-4.0)	1.5 (0.6-3.7)	0.6 (0.1-3.0)	2.9 (0.9-10.0)	0.8 (0.3-2.1)	1.7 (0.9-3.4)
Wheezing in the absence of a cold	2.3 (0.5-9.5)	1.4 (0.5-3.7)	‡	‡	1.2 (0.3-4.3)	1.7 (0.7-4.0)
Tightness in chest when waking up	0.2 (0.0-1.9)	2.8 (1.1-7.3)*	0.4 (0.1-2.3)	1.1 (0.3-3.6)	0.3 (0.1-1.2)	1.7 (0.8.3.5)
Cough on winter mornings	1.1 (0.2-4.8)	2.0 (0.7-5.3)	2.3 (0.5-10.6)	0.6 (0.2-2.0)	1.4 (0.5-4.0)	1.1 (0.6-2.4)
Phlegm on winter mornings	0.5 (0.1-2.2)	6.5 (2.3-18.1)**	‡	‡	0.6 (0.2-1.5)	3.0 (1.5-5.9)*
Dyspnoea on exertion	1.1 (0.3-4.5)	5.1 (1.9-13.2)**	1.3 (0.3-5.7)	1.0 (0.3-3.2)	1.1 (0.4-3.1)	2.3 (1.1-4.5)*
Watery or itchy eyes	1.7 (0.5-6.1)	2.1 (0.9-5.4)	‡	‡	0.9 (0.3-2.6)	1.4 (0.7-2.8)

† Ratios controlled for age, smoking category, and exposure to ETS
‡ Not enough cases available
* p<0.05, ** p<0.001

Analysis of data

Initial bivariate analyses examined the prevalence of specific conditions overall and by age and sex. Unconditional logistic regression analysis was used to identify exposures related to symptoms, controlling for confounding. Only a few respondents <18 years old were current smokers and none were ex-smokers. Those <18 years old and those ≥18 years old were, therefore, examined separately, and many analyses were limited to those ≥18 years of age.

RESULTS

Just over half the respondents were female (n=212, 53%) (Table I). The average age was 25.5 years (SD=19.4) with a substantial number under 9 years old (n=102, 25%) and relatively few ≥50 years old (n=46, 11%). About half were non-smokers. Of those ≥18 years of age, 20% were non-smokers, 71% were current smokers, and 8% were ex-smokers. Relatively few respondents <18 were listed as ever having smoked. This may have resulted from the fact that many questionnaires were administered in a family setting and some youth may not have wanted to admit to smoking. Over 40% of participants spent ≥5 hours a day in areas contaminated by environmental tobacco smoke (ETS) and only 21% were not exposed to ETS.

Exposure to indoor wood smoke was equally distributed by gender and age. Smokers were more likely to report exposure to indoor wood smoke. More women (42%) were engaged in smoke curing of meat and hides than men (31%). Involvement in smoke curing increased with age. Smokers were more likely to be exposed. This was also observed for self-reported exposure to outdoor wood smoke.

Symptom prevalence was low for those <18 years old (Table II). Prevalence was higher among adults and women for wheezing during the last 12 months and in the absence of a cold, dyspnoea on exertion, and watery or itchy eyes. ORs for respiratory symptoms were greater for females. Smoking was strongly related to all symptoms except watery or itchy eyes (not presented).

Among those at least 18 years old, phlegm on winter mornings, dyspnoea, and watery or itchy eyes were significantly related to self-reported outdoor wood smoke and smoke curing: adjusted ORs 2.3-4.2 (Table III). ORs for women were generally higher than those for men. In addition, women involved in curing/tanning had elevated risk for chest tightness (Table IV). Exposure to wood-fueled furnaces did not show significant associations with any symptoms. Additional control for pack-years, smoke curing (for indoor exposure), and heating system (for outdoor exposure) did not change the ORs.

Drafts in the house were reported by 41% of participants. Drafts were significantly related to a number of symptoms. However, controlling for drafts did not substantially alter the ORs of the other variables. The exception was wheezing in the absence of a cold for women with self-reported exposure to indoor wood smoke which became statistically significant when controlled for draftiness (OR=3.5, 95% CI: 1.0-11.6). Since the start of the heating season fell within the study period, the ORs were additionally controlled for the month of questionnaire completion. Neither the significance levels nor the ORs changed substantially.

DISCUSSION

Respiratory symptoms were common among the residents of Deline. Dyspnoea on exertion and phlegm on winter mornings were the most common symptoms (both 21%), followed by wheezing during the last 12 months (20%), cough and watery or itchy eyes (both 18%). However, the prevalence of cough and phlegm was lower than that found among women in highland Guatemala who used open wood fires or wood-burning chimney stoves for cooking.[14]

Women involved in smoke curing had a 6.5-fold risk of phlegm on winter mornings. When self-reported exposure to outdoor wood smoke was analyzed, the association approached statistical significance. In recent studies, usual cough and phlegm were significantly related to cooking and heating with coal stoves,[15] use of open fires for cooking[14] and the frequency of heavy cooking fumes emitted by gas stoves among non-smoking women in Singapore.[16] Viegi et al. proposed that different perceptions and reporting of respiratory symptoms for males and females might explain why phlegm was generally a male, and dyspnoea a female characteristic.[17]

Dyspnoea on exertion was linked to exposures in the tipis.[18] ORs were significant for adult women involved in smoke curing and those reporting exposure to outdoor wood smoke. In a study of Nigerian fishermen and women, irritant and volatile components that could cause eye and skin irritation were emitted by fish during the drying process over burning firewood.[19] Ellegard concluded that tears while cooking were a useful determinant of indoor air pollution from cooking-related sources because eye irritation was more prevalent in environments with higher particulate pollution, and coincided with respiratory symptoms.[20] In the present study, women, who reported exposure to outdoor wood smoke, had an elevated risk of watery or itchy eyes. ORs for smoke curing were also elevated.

Indoor exposures failed to show any significant associations with symptoms. PM_{10} measurements showed varying yet not significantly different means for the residences heated by oil or wood in Deline.[14] Substantial differences in exposure would have been necessary to study differences in health outcomes effectively, as noted by Bruce et al.[14] While other studies have also failed to show significant associations between wood used for cooking and respiratory symptoms,[21,22] the available data suggest a causal relationship between wood smoke and adverse respiratory health outcomes in young children.[11]

No direct measurements of exposure to wood smoke were carried out at an individual level, relying instead on self-reporting or proxy measures. The differing exposure assessments did not lead to congruent exposure groups. Despite these inaccuracies, the consistency of the results (at least between the two outdoor exposure measures) and their uniformity with the existing literature suggest that they may be accurate measures. The ORs for the two indoor exposure variables, on the other hand, differed, with generally higher ORs for those self-reporting an exposure than for residents in homes with wood-fueled stoves (Tables III and IV). Failure to consider a wood stove as an exposure to wood smoke may relate to the stoves themselves or the amount of time they were used.

Based on these data, it is apparent that women engaged in smoke curing in tipis are at excess risk of respiratory symptoms. The importance of curing meat and tanning hides in the local culture and economy argues against abandoning the activity for health reasons. Health benefits could presumably be achieved by limiting the time working in tipis or modifying the process to reduce exposures. Efforts to decrease cigarette smoking would also improve respiratory health in this community.

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RÉSUMÉ

Contexte : La fumée de bois est associée à divers symptômes d'atteinte de l'appareil respiratoire. Nous avons étudié la prévalence des symptômes respiratoires et les effets sur la santé de l'exposition à la fumée de bois (provenant du chauffage domestique, du fumage des viandes et du tannage des peaux) chez les résidants de Deline (Territoires du Nord-Ouest).

Méthode : Sondage auprès de tous les résidants et examen des liens entre la fumée de bois et les symptômes respiratoires.

Résultats : Le taux de réponse était de 70,2 % (n=402). Soixante-et-onze p. cent des personnes de 18 ans et plus étaient des fumeurs actuels. La prévalence des symptômes était supérieure chez les femmes (rapports de cotes [RC] de 1,3-3,1). Les fumeuses étaient aussi plus susceptibles d'être exposées à la fumée provenant du fumage et du tannage à l'intérieur des habitations. Les RC des symptômes respiratoires étaient supérieurs chez les femmes, augmentaient avec l'âge et étaient très influencés par le tabagisme. Chez les femmes de 18 ans et plus, la mucosité les matins d'hiver (6,5 [IC de 95 % = 2,3-18,1]), la dyspnée (5,1 [IC de 95 % = 1,9-13,2]) et le larmoiement ou les yeux qui piquent (3,6 [IC de 95 % = 1,4-9,0]) présentaient des liens significatifs avec la fumée de bois à l'extérieur et le fumage déclarés par les intéressées. Le chauffage domestique présentait un lien marginal avec la respiration sifflante. Aucune association significative n'a été constatée chez les hommes.

Conclusions : La prévalence des symptômes respiratoires était plus élevée chez les femmes qui s'adonnaient au fumage ou au tannage. L'importance culturelle de ces activités écarte la possibilité qu'elles soient abandonnées, mais le renoncement au tabac, la réduction des durées d'exposition à la fumée de bois et la modification des méthodes de fumage et de tannage pourraient réduire le risque d'effets indésirables sur la santé.

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