Indoor Risk Factors for Cough and Their Relation to Wheeze and Sensitization in Chilean Young Adults

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Objectives. We assessed the effects of indoor risk factors, including smoking, on different types of cough and on cough and wheeze in combination.

Methods. Our sample was composed of 1232 men and women residing in a semirural area of Chile. We used a standardized questionnaire, sensitization to 8 allergens, and bronchial hyperresponsiveness to methacholine to assess cough and wheeze characteristics. Information was gathered on dampness, mold, ventilation, heating, housing quality, smoking, and environmental tobacco smoke exposure.

Results. Most exposures were associated with cough alone or cough in combination with wheeze. Smoking, past smoking, and environmental tobacco smoke exposure were strongly associated with dry cough and wheeze. The use of coal for heating was associated with dry cough. Leaks, mold, and lack of kitchen ventilation were associated with cough and wheeze. Nocturnal cough and productive cough were associated with specific types of sensitization, but dry cough was not. Productive cough was associated with hyperresponsiveness to methacholine.

Conclusions. Several different types of indoor exposures, including environmental tobacco smoke exposure, are important contributors to morbidity associated with cough and wheeze. A vigorous preventive strategy designed to lower exposures to indoor risk factors would lower rates of respiratory morbidity. (*Am J Public Health.* 2008;98:680–686. doi:10.2105/AJPH.2006.093302)

Cough is an important public health problem in Latin America because chronic obstructive pulmonary disease, smoking, and asthma symptoms are common.[1–3] However, epidemiological studies focusing on the etiology of cough in Latin America are rare.[4]

Cough, a common symptom in many respiratory conditions, affects more than 10% of the population worldwide.[5–8] However, it has not been assessed systematically in relation to exposure to household risk factors such as environmental tobacco smoke, lack of ventilation, mold, dampness, and the use of particular heating and cooking fuels.[9–17] When cough has been assessed, it has been in the context of only 1 of several respiratory symptoms in reports focusing on a particular type of exposure. This approach has not disentangled the extent to which each type of exposure relates to a specific type of cough (productive, dry, or nocturnal).

Indeed, whether a cough is productive or dry or whether it occurs during the daytime or nighttime may be indicative of different diseases and may be a specific response to a particular type of exposure. This lack of differential diagnosis was recognized in one population-based study of respiratory health in young European adults,[5] but that investigation primarily focused on variations associated with smoking and environmental tobacco smoke exposure between the study centers.

The usual study approach has been to isolate cough from other symptoms, with the exception of phlegm, or restrict assessments to those with chronic bronchitis.[9,11–15,17,18] Little attention has been given to whether the cough's presentation is isolated or accompanied by other respiratory symptoms such as wheeze in relation to exposure.[19] Such an approach would help determine whether responses to a set of exposures are specific in terms of the characteristics of cough and, if so, uncover the accompanying symptoms and reveal what objective tests, such as sensitization and bronchial hyperresponsiveness measures, would be relevant to particular types of cough.

We used the standardized European Community Respiratory Health Survey (ECRHS) questionnaire to assess a series of respiratory symptoms among young adults living in a semirural area of Chile and collected information on types of housing, heating and cooking fuels, house dampness, mold presence, kitchen ventilation, smoking, and exposure to environmental tobacco smoke.[20,21] We assessed associations between these types of indoor exposures and types of cough (productive, dry, or nocturnal). Also, because wheeze is the most commonly studied asthma symptom, we analyzed the interrelations between each type of cough and particular exposures in the presence of wheeze in the past 12 months. In addition, we assessed whether each type of cough was associated with a particular type of sensitization.

METHODS

Sample

Our study took place between January 2001 and April 2003. A sample of 1232 men and women was randomly selected from a sampling frame of 3096 births occurring between 1974 and 1978 in the maternity unit of the Limache Hospital in Chile, which serves a population of approximately 52 000 inhabitants living in Olmue and Limache. The community of Limache, located 120 km northwest of Santiago, primarily exports agricultural products, and its poverty level is similar to the median for the country.[20]

Participants were aged between 22 and 28 years at the time of the survey.[21,22] As a result of emigration, death, unwillingness to take part, and more rarely, a prison sentence or disability, the original sampling frame was used to randomly replace approximately 21% of the participants.

Outcome Measures

We used the ECRHS questionnaire, translated into Spanish and modified to reflect local conditions, to assess respiratory symptoms and environmental exposures.[23] Participants were invited to the clinic for a face-to-face interview; all interviews were conducted by a trained fieldworker to ensure full comprehension of the questions asked.

Symptoms assessed were wheeze in the past 12 months, being woken by a cough attack (nocturnal cough) in the past 12 months, a productive cough with phlegm, and a dry (nonproductive) cough. Participants were defined as having a productive cough if, in addition to responding yes to "Do you usually cough first thing in the morning in winter?" or "Do you usually cough during either the day or night in the winter?" they responded yes to either "Do you usually bring up any phlegm from your chest first thing in the morning in the winter?" or "Do you usually bring up any phlegm from your chest during either the day or night in the winter?" Participants were classified as having a dry cough if they answered no to both of the latter 2 questions after answering yes to either of the initial cough questions.

Sensitization and Bronchial Hyperresponsiveness

We assessed, through skin tests, sensitization to cat fur, dog hair, cockroaches, *Dermatophagoides pteronyssinus* (a type of house dust mite), *Alternaria alternata* (an important cause of mold allergies in humans), and blends of pollens from grasses, trees, and weeds.[21,22] A mean welt size of at least 3 mm was considered positive. Eight participants were eliminated from the analysis because they reacted to the control negative (an uncoated Phazet).

We used the tidal breathing method to assess bronchial hyperresponsiveness challenges to methacholine.[24] A positive bronchial hyperresponsiveness result was defined as a decrease of 20% in comparison with the best value at baseline of forced expiratory volume in 1 second at any concentration of methacholine up to 16 mg/mL ($PC_{20} \leq 16$ mg/mL).

Exposure Measures

Type of housing, type of heating, household leaks, mold presence, kitchen ventilation, smoking, and environmental tobacco smoke exposure were considered in terms of their relation to respiratory symptoms. Housing was classified into 6 groups: solid houses with 4 or more rooms, solid houses with 2 or 3 rooms, basic social homes, wooden houses with 2 rooms, wooden houses with 3 or more rooms, and ramshackle dwellings. Solid houses were defined as houses that were built primarily from concrete or brick and had tiled roofs. Basic social homes were defined as small houses or apartments built as part of a government social project aimed at providing basic accommodation to families with incomes below the poverty line; the unit cost of these homes could not exceed the equivalent of US $13 500. Ramshackle dwellings were semipermanent structures made from poor-quality materials such as wood, cardboard, polythene, or corrugated zinc.

Types of heating were classified as follows: coal, logs, gas, kerosene, electric, other, or none. In Limache, unvented braziers (open metal containers within which coal is burnt) are typically used in coal heating. Winter kitchen ventilation was assessed according to the frequency at which windows were opened during cooking. Household leaks in the past 12 months from broken pipes, roof leaks, and inundations from heavy rain were assessed.

Participants were grouped into 5 categories in terms of smoking status: never smokers, never smokers exposed to environmental tobacco smoke for at least 1 hour per day, exsmokers who had stopped smoking for at least 1 month, light smokers (fewer than 5 cigarettes per day), and moderate or heavy smokers (5 or more cigarettes per day). All exsmokers were classified as such irrespective of whether or not they were exposed to other people's cigarette smoke. Data on the effects of smoking on respiratory symptoms other than cough have been published elsewhere.[25]

Fieldwork Procedures

Fieldworkers located individuals identified as possible study participants using mother's address at the time of delivery or clinical notes; if these sources were unavailable, they used informal procedures such as contacting relatives, neighbors, or other members of the community. Once located, these individuals were invited to participate in the study and offered an appointment.

Initially, participants completed an administered questionnaire in a clinical setting. Afterward, anthropometric measurements were taken, skin-prick tests were conducted, and lung function and bronchial hyperresponsiveness were assessed. The entire face-to-face appointment required approximately 3 hours to complete. Registered nurses trained in each aspect of the study performed all procedures.

Statistical Analysis

Multinomial logistic regression (also referred to as polytomous logistic regression), an extension of multiple logistic regression that allows for inclusion of more than 2 categories of the dependent variable, was used in carrying out all of the primary analyses.[26] This method allowed us to combine each type of cough and wheeze in the past 12 months and assess associations with the independent variables. We conducted 3 main analyses, combining as dependent variables productive cough and wheeze, dry cough and wheeze, and nocturnal cough and wheeze.

The independent factors included in the model were type of housing, type of heating, leaks in the past 12 months, open windows during cooking, mold on any surface other than food, smoking status, and environmental tobacco smoke exposure. We adjusted for the indoor exposure variables along with season of interview, gender, age, body mass index (weight in kilograms divided by height in meters squared), and number of years of full-time education (as a measure of socioeconomic background).

We also carried out multiple logistic regression analyses to assess the association of each type of cough and wheeze with sensitization and positive bronchial hyperresponsiveness results. We examined interactions between variables to assess whether the associations of any of these factors with symptoms were different among men and women and between smokers and nonsmokers.

RESULTS

Table 1 shows percentage distributions of respiratory symptoms, sensitization, positive bronchial hyperresponsiveness results, and environmental exposures. All types of cough and wheeze in the past 12 months were common, with approximately one quarter of the participants exhibiting sensitization and approximately 13% having positive bronchial hyperresponsiveness results. Most participants lived in basic social dwellings and noninsulated wooden houses. Half of the participants did not have any type of heating in their house, and the majority used gas for cooking.

TABLE 1—Distribution of Respiratory Symptoms, Sensitization, and Environmental Exposures in Adults Aged 22 to 28 Years (n = 1232): Limache, Chile, 2001–2003

Risk Factor/Symptom	Men, no. (%)	Women, no. (%)	Total, no. (%)
Respiration			
Nocturnal cough	177 (31.7)	275 (40.9)	452 (36.7)
Dry cough	66 (11.8)	113 (16.9)	179 (14.5)
Productive cough	142 (25.4)	116 (17.2)	258 (20.9)
Wheeze in past 12 mo	149 (26.7)	188 (27.9)	337 (27.3)
Skin test sensitization			
Cats	23 (4.1)	43 (6.5)	66 (5.4)
Dermatophagoides pteronyssinus[a]	87 (15.6)	86 (12.9)	173 (14.1)
Grass	66 (11.9)	50 (7.5)	116 (9.5)
Trees	40 (7.2)	40 (6.0)	80 (6.5)
Cockroaches	29 (5.2)	24 (3.6)	53 (4.3)
Dogs	12 (2.2)	15 (2.3)	27 (2.2)
Alternaria alternata[b]	12 (2.2)	17 (2.6)	29 (2.4)
Weeds	43 (7.7)	41 (6.2)	84 (6.9)
Any	143 (25.7)	168 (25.2)	311 (25.4)
Bronchial hyperresponsiveness	45 (8.1)	111 (16.5)	156 (12.7)
Type of housing[c]			
Solid house, ≥ 4 rooms	25 (4.5)	27 (4.0)	52 (4.2)
Solid house/apartment, 2–3 rooms	113 (20.2)	107 (15.9)	221 (17.9)
Basic social home	167 (29.9)	215 (32.0)	382 (31.0)
Wooden house, ≥ 3 rooms	202 (36.1)	238 (35.4)	440 (35.7)
Wooden house, 2 rooms	47 (8.4)	74 (11.0)	121 (9.8)
Ramshackle dwelling	4 (0.7)	11 (1.6)	15 (1.2)
Type of heating fuel			
None	223 (39.9)	285 (42.4)	509 (41.3)
Coal	31 (5.6)	24 (3.6)	55 (4.5)
Logs	40 (7.2)	47 (7.0)	87 (7.1)
Gas	102 (18.3)	125 (18.6)	227 (18.4)
Kerosene	112 (20.0)	104 (15.5)	216 (17.5)
Electric	34 (6.1)	56 (8.3)	90 (7.3)
Other	17 (3.0)	32 (4.8)	49 (4.0)
Type of cooking fuel			
Coal or logs	17 (3.0)	16 (2.4)	33 (2.7)
Gas	541 (96.8)	655 (97.3)	1197 (97.1)
Mold (on any surface other than food)	182 (32.6)	300 (44.6)	482 (39.1)
Leaks (from pipes or heavy rain)	181 (32.4)	217 (32.2)	398 (32.3)
Window open during cooking			
Always	276 (49.4)	349 (51.9)	622 (50.5)
A few hours per day	176 (31.5)	221 (32.8)	397 (32.2)
Rarely	25 (4.5)	24 (3.6)	49 (4.0)
Not at all	70 (12.5)	66 (9.8)	136 (11.0)
Smoking status			
Never smoker	91 (16.6)	179 (27.1)	270 (21.9)
Never smoker exposed to ETS	57 (10.4)	115 (17.4)	172 (14.0)
Ex-smoker	21 (3.8)	35 (5.3)	56 (4.6)
Light smoker (< 5 cigarettes/d)	204 (37.2)	233 (35.3)	437 (35.5)
Moderate or heavy smoker (≥ 5 cigarettes/d)	175 (31.9)	99 (15.0)	274 (22.2)

Note. ETS = environmental tobacco smoke.
[a]*Dermatophagoides pteronyssinus* is a type of house dust mite.
[b]*Alternaria alternata* is an important cause of mold allergies in humans.
[c]Housing was classified into 6 groups: solid houses with 4 or more rooms, solid houses with 2 or 3 rooms, basic social homes, wooden houses with 2 rooms, wooden houses with 3 or more rooms, and ramshackle dwellings. Solid houses were defined as houses that were built primarily from concrete or brick and had tiled roofs. Basic social homes were defined as small houses or apartments built as part of a government social project aimed at providing basic accommodation to families with incomes below the poverty line; the unit cost of these homes could not exceed the equivalent of US $13 500. Ramshackle dwellings were semipermanent structures made from poor-quality materials such as wood, cardboard, polythene, or corrugated zinc.

One third of the participants were exposed to dampness as a result of leaking pipes or heavy rain, and 39% reported exposure to mold.

Women reported a greater frequency of nocturnal coughing and dry coughing than did men, but men reported a greater frequency of productive coughing. Smoking was common among both men and women, but more men than women smoked at least 5 cigarettes a day. Women more often reported mold exposure than men, probably because they were more aware of this household hazard.

The only factors associated with productive cough at the borderline level of significance were closed kitchen windows during cooking ($P=.061$) and residence in a ramshackle dwelling ($P=.054$; Table 2). Smoking 5 or more cigarettes a day ($P<.001$) and exposure to household leaks ($P=.002$) were associated with wheeze and productive cough. The odds ratio for past smoking was high, but the confidence interval was too broad to infer an association. Exposure to leaks ($P=.013$), smoking (regardless of amount; $P=.002$), and exposure to mold ($P=.058$) were associated with wheeze, and this pattern was also seen in analyses focusing on nonproductive cough and nocturnal cough.

Dry cough was associated with use of coal for heating ($P=.007$) and weakly associated with smoking at least 5 cigarettes a day ($P=.055$; Table 3). Smoking (regardless of amount), past smoking ($P=.041$), and environmental tobacco smoke exposure ($P=.005$) were associated with wheeze and dry cough. Exposure to leaks ($P=.02$) and lack of kitchen ventilation ($P=0.03$) were also associated with these 2 symptoms, and the effect sizes were relatively strong.

There were positive associations between nocturnal cough and exposure to household leaks ($P=.062$) and residence in a basic social house ($P=.013$), and there was a negative association between nocturnal cough and residence in a wooden house with 2 rooms ($P=.056$; Table 3). Exposure to leaks ($P=.001$) and smoking (regardless of amount; $P<.001$) were strongly associated with wheeze and nocturnal cough.

Table 4 shows patterns of association with each type of allergen and positive bronchial hyperresponsiveness results. Nocturnal cough, productive cough, and wheeze

TABLE 2—Results of Multinomial Regression Analyses of Associations Between Selected Risk Factors and Wheeze, Productive Cough, and Both Symptoms Combined in Adults Aged 22 to 28 Years (n = 1232): Limache, Chile, 2001–2003

	Wheeze, OR (95% CI)	Productive Cough, OR (95% CI)	Wheeze and Productive Cough Combined, OR (95% CI)
Mold	1.39 (0.99, 1.95)	0.99 (0.64, 1.53)	1.40 (0.90, 2.20)
Leaks	1.49 (1.06, 2.10)	1.26 (0.82, 1.93)	1.87 (1.20, 2.91)
Coal heating	0.75 (0.31, 1.86)	0.96 (0.37, 2.46)	1.92 (0.81, 4.58)
Ventilation in winter			
Always	1.00	1.00	1.00
A few hours per day	1.04 (0.73, 1.49)	1.00 (0.64, 1.59)	1.12 (0.69, 1.80)
Rarely	0.97 (0.40, 2.31)	1.22 (0.45, 3.27)	0.94 (0.31, 2.81)
Windows not opened	0.69 (0.37, 1.26)	1.74 (0.97, 3.09)	1.58 (0.80, 3.10)
Type of housing[a]			
Solid house, ≥ 4 rooms	1.13 (0.71, 1.80)	0.67 (0.36, 1.25)	0.92 (0.48, 1.78)
Solid house/apartment, 2–3 rooms	0.76 (0.50, 1.15)	0.73 (0.44, 1.20)	0.90 (0.52, 1.56)
Basic social home	0.44 (0.17, 1.14)	0.37 (0.10, 1.33)	0.63 (0.19, 2.09)
Wooden house, ≥ 3 rooms	1.00	1.00	1.00
Wooden house, 2 rooms	0.88 (0.49, 1.58)	0.91 (0.46, 1.80)	1.11 (0.53, 2.33)
Ramshackle dwelling	. . .[b]	3.37 (0.98, 11.61)	0.79 (0.14, 4.55)
Smoking status			
Never smoker	1.00	1.00	1.00
Never smoker exposed to ETS	1.47 (0.82, 2.65)	0.65 (0.32, 1.31)	1.30 (0.55, 3.08)
Ex-smoker	1.84 (0.77, 4.39)	1.60 (0.65, 3.91)	2.31 (0.72, 7.42)
Light smoker (<5 cigarettes/d)	2.12 (1.31, 3.42)	0.81 (0.48, 1.37)	1.67 (0.82, 3.39)
Moderate or heavy smoker (≥5 cigarettes/d)	3.00 (1.77, 5.07)	0.98 (0.54, 1.76)	5.19 (2.55, 10.55)

Note. OR = odds ratio; CI = confidence interval; ETS = environmental tobacco smoke. Values were adjusted for the variables shown in addition to gender, age, educational level, geographical location, season, and body mass index.
[a]Housing was classified into 6 groups: solid houses with 4 or more rooms, solid houses with 2 or 3 rooms, basic social homes, wooden houses with 2 rooms, wooden houses with 3 or more rooms, and ramshackle dwellings. Solid houses were defined as houses that were built primarily from concrete or brick and had tiled roofs. Basic social homes were defined as small houses or apartments built as part of a government social project aimed at providing basic accommodation to families with incomes below the poverty line; the unit cost of these homes could not exceed the equivalent of US $13 500. Ramshackle dwellings were semipermanent structures made from poor-quality materials such as wood, cardboard, polythene, or corrugated zinc.
[b]There were too few residents to allow calculation of odds ratio.

were associated or weakly associated with several allergens, but dry cough was not related to any of the allergens assessed. Positive bronchial hyperresponsiveness results were associated with productive cough ($P = .013$) and wheeze ($P = .003$) but were not related to dry cough or nocturnal cough. We tested interactions between each exposure and gender for the outcomes of interest; none of these interactions were statistically significant.

DISCUSSION

Smoking, past smoking, and exposure to environmental tobacco smoke were strongly associated with dry cough and wheeze. Exposure to household leaks was associated with cough regardless of type of cough and presence of wheeze. Lack of kitchen ventilation was associated with productive cough and with dry cough and wheeze in combination. Use of coal as fuel was strongly associated with dry cough. There were several associations between type of housing and cough, but patterns were inconsistent and difficult to explain. For example, we do not know why residence in basic social homes was associated with nocturnal cough. One possibility is that this relationship reflects factors associated with socioeconomic background (i.e., poverty) rather than building materials per se.

Wheeze and productive cough were associated with specific allergens and positive bronchial hyperresponsiveness results. Nocturnal cough was also associated with allergens, but dry cough was not associated with allergens or positive bronchial hyperresponsiveness results. As in most investigations, we found that dry cough was more frequent among women[27]; however, productive cough was more frequent among men, a finding consistent with the lack of difference between genders in the ECRHS.[5]

Previous studies have shown that smoking is related to dry, productive, and nocturnal cough,[5,28,29] as well as chronic bronchitis (persistent productive cough).[18,29,30] In our study, smoking effect sizes were greater when participants reported both cough and wheeze, varying from an odds ratio of 4.5 among those reporting nocturnal cough to an odds ratio of 8.9 among those reporting dry cough. These associations were also found among those who smoked fewer than 5 cigarettes a day.

In an earlier study involving adolescents, smoking was shown to contribute independently to symptoms of wheeze and cough.[31] In a study conducted in South Africa, a country with a per capita income similar to that of Chile, smoking was associated with chronic bronchitis, but the effect size was smaller than in our study.[18] Our multinomial approach to cough analyses uncovered a strong association between past smoking and wheeze and dry cough and a nonsignificant association with nocturnal and productive cough. Other studies have not reported this association in relation to productive cough[18,30] or any other type of cough.[5] To our knowledge, however, multinomial analyses have been used in only 1 previous study, and that study focused on rhinitis and cough.[19]

Environmental tobacco smoke exposure has not been found to be consistently associated with respiratory symptoms in adults.

TABLE 3—Results of Multinomial Regression Analyses of Associations of Selected Risk Factors With Dry Cough, Wheeze, and Nocturnal Cough in Adults Aged 22 to 28 Years (n = 1232): Limache, Chile, 2001–2003

	Dry Cough, OR (95% CI)	Dry Cough and Wheeze Combined, OR (95% CI)	Nocturnal Cough, OR (95% CI)	Nocturnal Cough and Wheeze Combined, OR (95% CI)
Mold	1.13 (0.74, 1.73)	1.65 (0.91, 2.99)	1.15 (0.83, 1.59)	1.49 (1.04, 2.15)
Leaks	0.90 (0.57, 1.41)	2.00 (1.11, 3.61)	1.38 (0.98, 1.92)	1.84 (1.29, 2.64)
Coal heating	3.40 (1.41, 8.21)	2.35 (0.67, 8.27)	1.18 (0.55, 2.54)	1.75 (0.81, 3.78)
Ventilation in winter				
Always	1.00	1.00	1.00	1.00
A few hours per day	1.39 (0.89, 2.17)	1.49 (0.78, 2.85)	1.01 (0.71, 1.43)	1.17 (0.80, 1.71)
Rarely	1.25 (0.44, 3.53)	3.69 (1.15, 11.88)	0.78 (0.33, 1.86)	0.75 (0.29, 1.94)
Windows not opened	1.00 (0.51, 1.96)	1.37 (0.54, 3.49)	0.87 (0.52, 1.46)	0.92 (0.51, 1.64)
Type of housing[a]				
Solid house, ≥ 4 rooms	0.86 (0.44, 1.67)	2.67 (1.21, 5.87)	0.75 (0.46, 1.22)	0.93 (0.55, 1.55)
Solid house/apartment, 2–3 rooms	1.54 (0.93, 2.55)	1.01 (0.47, 2.18)	0.98 (0.67, 1.44)	0.80 (0.51, 1.24)
Basic social home	1.32 (0.49, 3.57)	0.27 (0.03, 2.63)	2.48 (1.21, 5.07)	0.75 (0.27, 2.09)
Wooden house, ≥ 3 rooms	1.00	1.00	1.00	1.00
Wooden house, 2 rooms	1.51 (0.73, 3.11)	0.77 (0.24, 2.50)	0.55 (0.30, 1.02)	1.06 (0.59, 1.91)
Ramshackle dwelling	1.91 (0.46, 7.98)	. . .[b]	0.33 (0.07, 1.61)	0.13 (0.01, 1.08)
Smoking status				
Never smoker	1.00	1.00	1.00	1.00
Never smoker exposed to ETS	1.03 (0.51, 2.06)	3.53 (1.10, 11.36)	0.73 (0.44, 1.21)	1.36 (0.71, 2.63)
Ex-smoker	1.05 (0.37, 3.03)	7.45 (1.91, 29.14)	0.83 (0.38, 1.82)	1.78 (0.70, 4.50)
Light smoker (<5 cigarettes/d)	1.28 (0.74, 2.21)	4.27 (1.51, 12.08)	0.81 (0.54, 1.22)	2.23 (1.32, 3.77)
Moderate or heavy smoker (≥5 cigarettes/d)	1.83 (0.99, 3.38)	9.53 (3.24, 28.07)	1.28 (0.80, 2.04)	4.51 (2.56, 7.94)

Note. OR = odds ratio; CI = confidence interval; ETS = environmental tobacco smoke. Results for wheeze in isolation were similar to those shown in Table 2 and are not presented here. Values were adjusted for the variables shown along with gender, age, educational level, geographical location, season, and body mass index.

[a]Housing was classified into 6 groups: solid houses with 4 or more rooms, solid houses with 2 or 3 rooms, basic social homes, wooden houses with 2 rooms, wooden houses with 3 or more rooms, and ramshackle dwellings. Solid houses were defined as houses that were built primarily from concrete or brick and had tiled roofs. Basic social homes were defined as small houses or apartments built as part of a government social project aimed at providing basic accommodation to families with incomes below the poverty line; the unit cost of these homes could not exceed the equivalent of US $13 500. Ramshackle dwellings were semipermanent structures made from poor-quality materials such as wood, cardboard, polythene, or corrugated zinc.

[b]There were too few residents to allow calculation of odds ratio.

We documented an association between environmental tobacco smoke exposure and wheeze and dry cough in combination but not in separate analyses of these 2 symptoms. The odds ratio for this association was 3.53, but the 95% confidence interval was too wide to make specific claims about the effect size. This finding was unexpected because houses in Chile are commonly poorly insulated and hence well ventilated, especially in less wealthy sectors of the population.

In the ECRHS, a small environmental tobacco smoke effect was shown that was consistent among participating centers in regard to dry cough but heterogeneous in regard to productive cough[5,32]; a Spanish study showed no such association.[30] In a Chinese study, environmental tobacco smoke exposure was associated with persistent dry cough, but research has shown that men in China may smoke more than men in other countries.[13] In a previous study in which we did not include cough in our analyses, there was no association between environmental tobacco smoke exposure and wheezing or waking up with breathlessness at night.[25]

The American College of Chest Physicians recently conducted an exhaustive review of diagnosis and management of cough; the contributors emphasized the association between smoking and environmental tobacco smoke exposure and cough because of chronic bronchitis[8] but did not mention the possible effects of smoking and environmental tobacco smoke exposure on dry cough and the large effect size in regard to dry cough and wheeze combined. Indeed, we were unable to locate studies examining the impact of smoking on a combination of symptoms including cough.

Our results are surprising considering that the Global Initiative for Chronic Obstructive Lung Disease[33] proposed that the risk stage for this disease is characterized by cough and sputum production with normal spirometry but made no reference to the effect of smoking on dry cough, an effect found in another study.[5] However, a recent position paper discussing chronic obstructive pulmonary disease recommended spirometry of smokers in the presence of cough in general, implying either productive or nonproductive cough.[34] We found that, in contrast to productive cough, nonproductive cough was not related to any allergen or to positive bronchial hyperresponsiveness results. This result would indicate that dry cough may not be associated with asthma, whereas in some cases, productive cough may be indicative of asthma.[35]

Our results confirmed that the use of coal in a close environment is an important etiological factor in regard to nonproductive cough. The association was found despite the low frequency of participants (fewer than 5%) who reported using coal as heating fuel. This relationship was also reported in a South African study (and, less convincingly, in a Chinese study), and the use of coal is a recognized cause of chronic bronchitis in underdeveloped countries.[9,13,18]

Poor kitchen ventilation was associated with an increase risk of productive cough as well as increased risks of dry cough and wheeze. This risk factor could be especially important for women, who may spend more time in the kitchen cooking. Lack of ventilation has also been shown to be associated with

TABLE 4—Skin Prick Sensitization and Bronchial Hyperresponsiveness Test Results in Adults Aged 22 to 28 Years (n = 1224): Limache, Chile, 2001–2003

	Nocturnal Cough, OR (95% CI)	Nonproductive Cough, OR (95% CI)	Productive Cough, OR (95% CI)	Wheeze in Past 12 Months, OR (95% CI)
Skin test sensitization				
Cats (n = 66)	1.20 (0.71, 2.04)	1.33 (0.69, 2.55)	1.86 (1.02, 3.42)	2.54 (1.48, 4.37)
Dermatophagoides pteronyssinus[a] (n = 173)	1.02 (0.72, 1.46)	0.92 (0.56, 1.49)	1.65 (1.09, 2.50)	1.91 (1.32, 2.77)
Grass (n = 116)	1.46 (0.97, 2.21)	1.20 (0.70, 2.08)	0.94 (0.56, 1.58)	1.53 (0.98, 2.38)
Trees (n = 80)	1.67 (1.03, 2.72)	1.10 (0.57, 2.12)	1.72 (0.96, 3.09)	1.93 (1.15, 3.22)
Cockroaches (n = 53)	2.27 (1.26, 4.12)	0.97 (0.42, 2.24)	1.56 (0.78, 3.10)	1.99 (1.07, 3.71)
Dogs (n = 27)	1.66 (0.74, 3.72)	1.00 (0.33, 3.01)	2.22 (0.91, 5.43)	1.08 (0.45, 2.58)
Alternaria alternata[b] (n = 29)	3.02 (1.35, 6.79)	1.13 (0.37, 3.40)	1.08 (0.40, 2.91)	1.95 (0.85, 4.46)
Weeds (n = 84)	1.58 (0.98, 2.54)	1.26 (0.68, 2.33)	1.23 (0.69, 2.20)	1.37 (0.82, 2.29)
Any (n = 311)	1.31 (0.99, 1.73)	1.14 (0.78, 1.65)	1.28 (0.91, 1.80)	1.63 (1.20, 2.20)
Bronchial hyperresponsiveness (n = 156)	1.31 (0.91, 1.90)	1.10 (0.68, 1.77)	1.74 (1.12, 2.69)	1.79 (1.21, 2.65)

Note. OR = odds ratio; CI = confidence interval. Values were adjusted for type of housing, type of heating, location, leaks, mold, season, smoking status, body mass index, gender, age, and educational level.
[a]*Dermatophagoides pteronyssinus* is a type of house dust mite.
[b]*Alternaria alternata* is an important cause of mold allergies in humans.

cough and phlegm,[13,20] and one study,[36] but not a second,[37] revealed an association between dual-paned windows and cough. These associations may be relevant mainly in the kitchen environment, in which individuals are exposed to the combustion of cooking fuels and the heating of food items and kitchenware. We cannot exclude the possibility that the positive association we found between windows rarely being opened and dry cough and the wheeze can be explained by a type II error, especially given that situations in which windows were never open were not associated with dry cough.

We found that damp housing and mold lead to increases in wheeze and cough regardless of type of cough. Only leaks were associated with nocturnal cough independently from wheeze. Information on leaks and molds was self-reported. Thus, it is reassuring that we were able to show that nocturnal cough was related to mold as well as to sensitivity to *A. alternata*. Several studies have reported an association between mold and respiratory symptoms,[11,15,16,37–40] and most of these studies have shown an association with cough.[11,15,16,38,39]

It is worth commenting on our results regarding the different profiles of each type of cough, as well as our sensitization and bronchial hyperresponsiveness findings. Dry cough was not related to sensitization or positive bronchial hyperresponsiveness results, but nocturnal cough and productive cough were associated with specific sensitizations and, in the case of productive cough, with positive bronchial hyperresponsiveness results. The profile of sensitizations, however, differed because nocturnal cough was related to *A. alternata* and cockroach exposures, whereas productive cough was associated with sensitization to pets and dust mites. The associations of sensitization and positive bronchial hyperresponsiveness results with nocturnal cough and productive cough indicate that these types of cough may be related to asthma, whereas dry cough may be related more to exposure to irritants.

Strength and Limitations

A strength of our large community study was the excellent response rate from a random sample. The study was led by interviewers so that fieldworkers (who were unaware of the hypotheses tested) would have the opportunity to ensure that participants had a good understanding of the questions. As with all questionnaire-based studies, however, certain information (e.g., data on dampness, mold presence, and kitchen ventilation) relied on participants' self-reports. Our finding that women more often reported mold presence may reflect between-gender differences in perception of the presence of this allergen. However, this limitation probably decreased the magnitude of any effects rather than producing misleading positive findings. Our study was carried out on a continuous basis, and the monitoring of symptoms and exposures over a lengthy interval could have reduced the associations observed between exposure factors and cough.

Information on smoking was based on participants' self-reports, but residents of rural areas of Chile are not likely to provide dishonest responses given that smoking prevention efforts are sporadic and individuals are not particularly inclined to hide their smoking. Finally, research has shown that it is difficult to gather data on duration of cough,[27] and we did not include a question assessing the length of time participants had experienced coughing.

Conclusions

Our study provides evidence that risk profiles are more pronounced when assessments focus on a combination of respiratory symptoms, namely cough and wheeze, than when they focus on either symptom alone. In particular, we were able to document strong effects of smoking and environmental tobacco smoke exposure on dry cough and wheeze, and these effects were found among ex-smokers as well. Moreover, we documented the effects of leaks, mold, lack of kitchen ventilation, and use of coal for heating on cough, sometimes in combination with wheeze. Replication of our results in countries with social circumstances similar to those of Chile would be helpful. We believe that a vigorous preventive strategy designed to minimize exposures to indoor risk factors would translate into marked reductions in respiratory morbidity. ■

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Contributors

J.F. Potts and R.J. Rona drafted the article and planned the analysis. R.J. Rona, M.J. Oyarzun, H. Amigo, and P. Bustos originated the project. H. Amigo and P. Bustos were responsible for supervising the implementation of the project, including data processing. M.J. Oyarzun was responsible for assessing bronchial hyperresponsiveness.

Human Participation Protection

Ethical approval for this study was obtained from the ethics committee of the Medical School of the University of Chile. All participants provided written informed consent.

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