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Poultry Processing Work and Respiratory Health of Latino Men and Women in North Carolina

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Abstract

Objective—To evaluate associations between poultry processing work and respiratory health among working Latino men and women in North Carolina.

Methods—Between May 2009 and November 2010, 402 poultry processing workers and 339 workers in a comparison population completed interviewer-administered questionnaires. Of these participants, 279 poultry processing workers and 222 workers in the comparison population also completed spirometry testing to provide measurements of forced expiratory volume in 1 second and forced vital capacity.

Results—Nine percent of poultry processing workers and 10% of workers in the comparison population reported current asthma. Relative to the comparison population, adjusted mean forced expiratory volume in 1 second and forced vital capacity were lower in the poultry processing population, particularly among men who reported sanitation job activities.

Conclusions—Despite the low prevalence of respiratory symptoms reported, poultry processing work may affect lung function.

Exposure to organic and inorganic dusts and other allergens is a well-recognized cause of airway disease among men and women employed in the agricultural industry.[1–4] In large-scale poultry production, workers inside poultry barns and processing plants encounter high levels of ammonia, bacteria, and dust on the job.[5–8] Because of the high concentrations of the exposures and their irritant properties, bronchial hyperresponsiveness,[9] coughing,[9,10] wheezing,[10] nasal symptoms,[11,12] and changes in lung function[5,8–10] have been investigated extensively among poultry barn workers.

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In contrast, relatively few data are available to describe inhalation exposures and respiratory health symptoms among individuals employed in poultry processing plants (ie, slaughterhouses, abattoirs), where live birds are received and then moved through the processing facility on a production line. Along the line, workers hang, kill, defeather, clean, eviscerate, and cut the poultry into parts that are then packaged, boxed, and shipped.[13,14] In addition to working on the line, employees clean machinery and floors; inspect and repair equipment; assemble boxes; and load, stack, and move pallets of packaged poultry. Throughout the facilities, workers may encounter cold temperatures and high humidity, and potential inhalation exposures include aerosolized chlorine compounds, cleaning agents, and machining and other fluids; airborne allergens, bacteria, dusts, endotoxin, and fungi; and carbon dioxide. The extent to which appropriate respiratory protection or mechanical ventilation systems are used in the poultry processing industry is unknown, though outbreaks of psittacosis and pneumonia[15–17] and reports of eye and respiratory tract irritation[5,13,18] suggest that workers' airways may not be sufficiently protected.

Previous epidemiologic research conducted in North Carolina has reported depressive symptoms,[19] dermatologic conditions,[20] and musculoskeletal problems[18,19,21] in the largely minority and immigrant poultry processing workforce, indicating that workers may be vulnerable to a range of occupational hazards. Our analyses build on these findings and the strong evidence of an association between poultry barn work and respiratory health by assessing self-reported respiratory symptoms and measurements of lung function among workers in the Latino poultry processing workforce in western North Carolina. We used these data to evaluate associations between poultry processing activities and respiratory health.

MATERIALS AND METHODS

Study Population

Between May 2009 and November 2010, we conducted a cross-sectional study among men and women living in communities surrounding three poultry processing plants in North Carolina. Potential participants were recruited in person by Spanish-speaking study personnel who visited homes selected randomly from a comprehensive listing developed by community-based study personnel to identify housing units with Spanish-speaking residents. Recruitment began with an original goal of enrolling 552 participants (276 poultry processing workers and 276 workers in other manual jobs), with equal numbers of men and women in each group. Recruitment of more than one participant from each housing unit was allowed. To meet the enrollment target for subsequent follow-up of the cohort, recruitment continued beyond the original goal. In total, 1681 housing units were visited and 1526 adults in 965 housing units were screened for eligibility; 957 of the individuals screened were eligible for participation.

Potential participants were eligible for inclusion if they were adults who self-identified as Latino or Hispanic (hereafter referred to as "Latino") and were employed and working in poultry processing or other manual labor jobs of 35 or more hours per week at the time of recruitment. Poultry processing was defined as nonsupervisory work in a poultry processing plant. The comparison population included individuals employed in a range of other jobs and recruited from the same communities. To be included in the comparison population, participants had to be employed for pay in manual jobs, excluding jobs in poultry processing or poultry production. Manual jobs included those in childcare, construction, hotels, landscaping, manufacturing, restaurants, and other service industries. Quality control workers in poultry processing plants and chicken catchers were excluded from both groups.

After screening for eligibility, trained data collectors successfully enrolled 742 (78%) individuals who completed face-to-face, interviewer-administered questionnaires. We excluded one participant (<1%) with missing information for the covariates included in our analysis, resulting in a final study population of 741 participants for analysis of questionnaire-based respiratory symptoms. Of these participants, 518 completed spirometry testing, which was conducted at data collection clinics scheduled in each of the communities within 1 month of when participants in the community completed the questionnaires. We excluded 17 participants (3%) whose spirometry testing yielded unusable results and our final population for the analysis of spirometry data includes 501 participants. The study methods and materials were approved by the Wake Forest University Health Sciences institutional review board and all participants provided written informed consent.

Occupational Exposures

In this analysis, the main exposure of interest was employment in poultry processing. In addition, each participant in the poultry processing population responded to survey questions designed to identify poultry-related activities that were part of his or her job. The list of activities included receiving, hanging, killing, plucking, cutting, eviscerating, washing-up, trimming, deboning, chilling, packing, sanitizing, and other activities. Participants who reported performing other activities were asked to specify their job activities; the reported activities included operating the production line, performing mechanic and utility-related tasks, sharpening knives, and performing other tasks as needed. Because of the small number of participants reporting several of the individual poultry processing activities, some activities were combined into groups (ie, receiving, hanging, killing, and plucking; cutting and evisceration; chilling and packing) corresponding to main production areas,[13] and each participant was categorized according to whether he or she performed any of the grouped activities.

Other potential inhalation hazards were identified using responses to a series of questions about participants' jobs and the materials that they handled at work. First, participants responded to a question about how frequently they worked in areas where they were exposed to dusts, smoke, gas, fumes, fibers, or other air pollutants (seldom/never, sometimes, often, or almost always/always). Participants then reported the hours per day, on average, that they worked with each of the following: animals, cleaning agents, dusts (eg, wood dust), glues or adhesives, oils or cutting fluids, paints and lacquers, plants, sealants, soil, or solvents (0, >0 to <½ hour, ½ to 2 hours, >2 hours).[22] We categorized those respondents who reported the frequency that they worked in areas with dusts, smoke, gas, fumes, fibers, or other air pollutants as "sometimes," "often," or "almost always/always" and those who reported working with any of the individual materials or exposures more than 0 hours per day as having other inhalation exposures. The use of respiratory protection at work was assessed using the survey question, How often do you use dust masks or respirators?

Respiratory Health

Respiratory health outcomes were assessed using questions from the Spanish translation of the European Community Respiratory Health Survey.[23] Participants were categorized as having a lifetime history of allergies if they responded positively to any of three allergy-related questions: Has a doctor ever diagnosed you with an allergy?, Have you ever had hay fever or other symptoms of nasal allergy (eg, from pollens or animals)?, and Have your eyes ever shown allergic symptoms like tears or redness from pollens or animals? All participants with positive responses to the question, Have you ever had asthma? were categorized as having asthma and those with positive responses to the follow-up question, Has it been diagnosed by a doctor? were categorized as having diagnosed asthma.

Participants also reported whether they experienced nasal allergies, wheezing or whistling in the chest, waking with a feeling of tightness in the chest, or being awoken by an attack of shortness of breath or coughing in the last 12 months; sought medical care for breathing problems such as these in the last 12 months; wheezed in the last month; were currently taking medication for breathing problems; and whether their breathing problems worsen when they work. We categorized participants as having nasal symptoms if they reported experiencing nasal allergies, including hay fever, in the last 12 months. We categorized participants as having current asthma if they gave positive responses about any of the following: (1) wheezing or whistling in the chest in the absence of a cold in the last 12 months, (2) waking due to an attack of shortness of breath at any time in last 12 months, (3) seeking medical care for breathing problems in the last 12 months, and (4) currently using medicine for breathing problems.

Spirometry was performed using EasyOne diagnostic spirometers connected to laptop computers running EasyWare 2008 version 2.11.6.0 and EasyWare 2010 version 2.21.0.0 (ndd Medical Technologies, Zurich, Switzerland). The spirometers were calibrated prior to each day of testing and spirometry methods followed the 2005 American Thoracic Society/European Respiratory Society guidelines.[24] Experienced technicians performed all spirometry testing with the assistance of study personnel who explained in Spanish, as needed, the purpose of the test and the testing procedures. Testing was performed with the participants seated. Data from all maneuvers were saved and later reviewed by study personnel (A.B.C. and M.C.M.). Spirometry measurements used in this analysis include forced expiratory volume in 1 second (FEV_1, in mL), forced vital capacity (FVC, in mL), and the ratio FEV_1:FVC. Predicted values of FEV_1 and FVC were calculated using equations for Mexican-American men and women published by Hankinson et al[25] and are presented as percentages of predicted FEV_1 and FVC volumes.

Statistical Analysis

Characteristics of the study population and prevalences of self-reported symptoms and conditions were assessed separately for poultry processing workers and the comparison population. We evaluated the associations of poultry work with nasal symptoms and current asthma using generalized estimating equations, specified with a binomial error distribution, a logit link, and an exchangeable structure for the correlation attributable to the recruitment of multiple participants within the same housing unit and clustered recruitment sites. We assessed age, allergy history, country of birth, respiratory protection use, sex, smoking status, and other inhalation exposures as potential confounders using a stepwise regression strategy in separate models evaluating the odds of nasal symptoms and current asthma, respectively, among all poultry processing workers relative to those in the comparison population. Variables that were statistically significant at $\alpha < 0.05$ were retained in our final models. Final models of associations between poultry work and nasal symptoms were adjusted for age and allergy history; final models of associations between poultry work and current asthma were adjusted for age, allergy history, sex, smoking status, and other inhalation exposures. Measures of association are reported as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). We conducted a sensitivity analysis to evaluate the effect of using $\alpha < 0.10$ to select covariates to be included in our final models. This change resulted in sex and other inhalation exposures being added to models of the association between poultry work and nasal symptoms and country of birth being added to models of the associations with current asthma.

Associations between poultry work and FEV_1, FVC, and the FEV_1:FVC ratio were evaluated for men and women separately using generalized estimating equation models specified with a normal error distribution, an identity link, and an independent structure for the correlation of data from participants recruited within housing units and recruitment sites. The sex-stratified models were adjusted for age, age squared, allergy history, height, height squared, smoking status, and other inhalation exposures. Associations of poultry work with FEV_1 and FVC as percentages of sex-specific predicted values were evaluated using similar models, adjusted for allergy history, smoking status, and other inhalation exposures.

For each symptom and lung function measure, we evaluated one model for the effect of poultry processing work overall, eight for the poultry processing activities, and one for the number of poultry processing activities reported (categorized as one activity or two or more activities). Models evaluating the poultry processing activities include only the poultry processing workers who reported the activity (or activities) and the comparison population; for example, models of the odds of nasal symptoms among workers who reported sanitation included 48 poultry processing workers and 339 members of the comparison population. Smoking status was categorized as lifetime nonsmoker, former smoker, or current smoker. One participant who did not provide smoking status information was categorized with the large majority of participants (72%) as a lifetime nonsmoker. All analyses were conducted using SAS version 9.1 (SAS Institute Inc, Cary, NC).

RESULTS

Characteristics of the study participants are shown in Table 1. Poultry processing workers were slightly older than workers in the comparison population (mean age, 35 vs 32 years, respectively; $P < 0.01$) and a larger proportion of participants in the poultry processing population reported their country of birth as Guatemala compared with the predominantly Mexican origin reported by the comparison population. The percentage of participants who reported work-related inhalation exposures was higher in the comparison population (74%) than in the poultry processing population (51%).

Table 2 shows the prevalence of reported nasal and respiratory symptoms and conditions. Overall, the lifetime prevalences of symptoms and conditions, as well as the prevalences in the last 12 months, were each higher in the comparison population than in the poultry processing population (eg, ever wheezing or whistling in the chest: 11% vs 8%, respectively). None of the differences, including the difference in prevalence of wheezing or whistling in the chest in the last month, current use of medication for breathing problems, and reporting that breathing problems worsen at work, was statistically different at the $\alpha = 0.05$ level.

Among the 402 poultry processing workers, packing (26%) and cutting (22%) were the most frequently reported poultry processing activities. Twenty-one percent reported performing two or more of the tasks as part of their poultry processing jobs (Table 3). Overall, the prevalences of nasal symptoms (prevalence, 25%; OR, 0.91; 95% CI, 0.59–1.40) and current asthma (prevalence, 9%; OR, 0.96; 95% CI, 0.57–1.62) were each lower among poultry processing workers than in the comparison population. Including sex and other inhalation exposures in models of the association between poultry processing and nasal symptoms modestly attenuated the effect estimates (including sex: OR, 0.91; 95% CI, 0.59–1.41; including other inhalation exposures: OR, 0.97; 95% CI, 0.62–1.52; including sex and other inhalation exposures: OR, 1.00; 95% CI, 0.63–1.57). Adding country of birth to the final model of the association between poultry processing and current asthma resulted in a negligible change in the adjusted OR (0.95; 95% CI, 0.55–1.63).

The small numbers of symptomatic participants limited our ability to evaluate thoroughly associations between individual poultry processing activities and nasal and respiratory symptoms. Nevertheless, the highest prevalences were observed among poultry processing workers who reported receiving, hanging, killing, and plucking (nasal symptoms: 35%); cutting and evisceration (nasal symptoms: 32%; current asthma: 12%); trimming (nasal symptoms: 33%); and chilling and packing (nasal symptoms: 34%; current asthma: 11%). Of these activities, multivariate analyses generated consistently elevated point estimates for cutting and evisceration (nasal symptoms: 1.10; current asthma: 1.50); trimming (nasal symptoms: 1.41; current asthma: 1.07); and chilling and packing (nasal symptoms: 1.57; current asthma: 1.23). Point estimates below unity were consistently observed for deboning (nasal symptoms: 0.61; current asthma: 0.64) and sanitation (nasal symptoms: 0.82; current asthma: 0.46) activities.

Among participants who completed spirometry testing, unadjusted mean values of FEV_1 and FVC were both higher in the comparison population (men: FEV_1, 3612 mL, FVC, 4382 mL; women: FEV_1, 2771 mL, FVC, 3281 mL) than in the population of poultry processing workers (men: FEV_1, 3337 mL, FVC, 4087 mL; women: FEV_1, 2612 mL, FVC, 3072 mL) (Table 4). Adjusted absolute differences in mean FEV_1 and FVC were lower among poultry processing workers overall and in nearly all of the poultry processing activity groups–most notably among all men (FEV_1, − 89 mL; FVC, − 84 mL) and men performing sanitation activities (FEV_1, − 192 mL; FVC, − 206 mL). Differences in the percentages of FEV_1 and

FVC predicted values and in the FEV_1:FVC ratio were modest across all categories, as were differences in FEV_1 and FVC with increasing numbers of poultry processing activities reported.

DISCUSSION

This large observational study provided us with a unique opportunity to report the prevalences of a wide range of respiratory health outcomes and measurements of lung function among working Latino men and women in rural North Carolina. In these data, employment in poultry processing was not associated with nasal symptoms or current asthma, though we observed lower prevalences of both in the poultry processing cohort than in the comparison population. In contrast, measurements of FEV_1 and FVC were modestly lower among female and male poultry processing workers and across categories of poultry processing job activities. The magnitudes of the differences were larger among men overall, and particularly among those who reported working in sanitation. Together, these findings suggest that despite the low prevalence of respiratory symptoms reported, poultry processing work may affect lung function.

The remarkably low prevalences of nasal and respiratory symptoms in the poultry processing cohort suggest that our study may be affected by a respiratory-specific healthy worker effect. If individuals who are eligible to work in poultry processing but who have allergies or respiratory health conditions that may be exacerbated by the potential exposures do not seek employment in poultry processing or have left poultry processing work, then the individuals employed in the facilities, and thus available for recruitment into this study, may be healthier than those employed elsewhere. Because of the wide range of manual labor jobs held by members of the comparison population, we do not expect the respiratory health or susceptibility profile of the comparison group to have been appreciably or systematically altered by the same phenomenon. This hypothesis is supported by the lower percentages of current smoking and lifetime histories of allergies, asthma, and wheezing in the poultry processing group than in the comparison group. Indeed, the associations between poultry work and respiratory symptoms generated in our study do not point to poultry processing work as a risk factor for adverse respiratory health.

In contrast, the consistently lower measures of FEV_1 and FVC in the poultry processing cohort suggest that, despite the low prevalence of symptoms reported, poultry processing may affect lung function. Because the differences in mean lung function measurements did not reach statistical significance among men or women, these data should be interpreted with caution. If the degree of lung function impairment observed in the poultry processing cohort was insufficient to trigger symptoms or other functional consequences, then this modest decline may indicate unrecognized respiratory disease. If participants experienced symptoms but did not report them in our survey, then our lung function findings may reveal systematic differences in the ways members of the two study populations reported symptoms. In both populations, median educational attainment was equivalent to a primary school education. Compared with other jobs available to Latino immigrants with limited education, jobs in poultry processing come with some noteworthy advantages. For example, working conditions were reported more favorably in the poultry processing cohort, where only 1% (vs 5% in the comparison population) reported having lost their job in the last year; 41% (vs 32%) reported having modified their work stations or tasks to make them safer or more comfortable; 87% (vs 60%) agreed that workers receive safety instruction when hired; 64% (vs 12%) reported having health insurance; and 25% (vs 4%) reported that the insurance was paid by their employer. If poultry processing jobs are considered more desirable than other employment opportunities available in the communities, then these jobs may be held by healthier workers, including men and women with less respiratory impairment and fewer functional consequences of the corresponding symptoms or conditions. Alternatively, individuals in these jobs may have better access to health care and fewer untreated symptoms or they may be reluctant to report symptoms that may be attributed to a relatively desirable job.

Few data about the respiratory health of poultry processing workers or rural Latino immigrants exist with which to compare our findings. Cross-shift increases in the prevalence of coughing (35% preshift vs 52% postshift), shortness of breath (0% vs 9%), nasal irritation (9% vs 22%), and runny nose (4% vs 17%) as well as decreases in FEV_1 (− 4.1% predicted) and FVC ((−3.1% predicted) have been reported in a small cohort of poultry slaughterhouse workers,[5] highlighting the importance of poultry processing exposures and the impact of the timing of symptom and lung function data collection. Thirty-day period prevalences of coughing or wheezing (11%) and shortness of breath (7%) have been reported in a poultry working cohort that included chicken catchers and processing workers.[18] In our data, 6% of the poultry processing population and 5% of the comparison population reported wheezing or whistling in the chest in the last month; these prevalences were both notably lower than that reported among Latino farmworkers (16%),[26] whose symptoms may be attributed to the wide range of outdoor exposures such as agricultural pesticides, allergens, and organic dusts encountered in farm work.[3,27–29]

In this study, assessment of potential inhalation exposures in the poultry processing plants was based on self-reported job activities. Our understanding of specific work tasks, as described by poultry processing workers in this study and by other accounts in the literature,[14,30,31] enabled us to develop plausible hypotheses about the relationships between poultry processing workplace exposures to respiratory irritants and respiratory symptoms. For example, workers who receive and handle live birds or carcasses likely encounter allergen, bacteria, and dust exposures. Air quality measurements from the breathing zones of slaughterhouse shacklers in Sweden indicated exposures to time-weighted average concentrations of total dust ranging from 0.4 to 15.3 mg/m^3 (mean, 6.3 mg/m^3), with higher levels of airborne bacteria in the hanging and evisceration departments than in the packaging areas.[5] As the birds are killed and continue along the assembly line, worker exposures to cold temperatures as well as vapors, gases, dusts, and fumes arising from disinfectants and other cleaning agents, machining fluids, and packaging materials may be expected throughout the plants. In these data, we observed lower metrics of lung function that support one task-specific hypothesis: The use of cleaning agents in the poultry processing affects lung function. This finding supports and extends a growing body of evidence that occupational exposure to cleaning agents with irritant properties affects lung function.[32,33] If our use of self-reported work activities or groupings of activities incorrectly grouped workers with varying degrees of exposure, the resulting misclassification likely limited the ability of our analysis to detect other potential effects. Developing and implementing methods to improve the assessment of exposures, including concentrations, durations, mixtures, and the use of respiratory protection and ventilation, would improve our understanding of the degree to which workers encounter inhalation hazards in various poultry processing jobs.

These data illustrate the importance and feasibility of including spirometry as one component of a large occupational health study. In fact, on the basis of the respiratory symptoms alone, the data may be viewed as suggesting that poultry work is associated with a lower burden of respiratory symptoms, whereas in combination with the available lung function measurements they suggest that poultry processing work may affect lung function. By presenting sex-stratified data, we also show lower lung function measurements, as a percentage of predicted values, among women than among men. This finding would be expected if women in the study experienced other inhalation exposures, such as those encountered in cooking, cleaning, gardening, and other avocational activities that were not accounted for in our data. Sex-based differences in these exposures would result in differential misclassification affecting our analysis of nasal and respiratory symptoms and may explain the lower lung function measures observed among women.

There are few large population-based surveys focused on occupational exposures and respiratory health of the Latino work-force in the United States. In this study, working Latino adults were successfully recruited and enrolled into a research study focused on the health of workers in an industry in which investigators and other public health personnel have limited workplace access. The generally low prevalence of respiratory health symptoms in the poultry processing cohort suggests the influence of the healthy worker effect. If poultry processing jobs are more desirable than other employment opportunities available, then those who leave poultry processing work due to their respiratory health may be at a unique employment disadvantage because of their health. These findings justify efforts to evaluate and monitor the health of new employees and to reduce exposures to inhalation hazards in poultry processing.

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TABLE 1

Characteristics of the Study Populations

	Poultry Processing Population	Comparison Population
Total	402	339
Demographic characteristics		
Age, yr		
Mean ± SD	35 ± 11	32 ± 9
Median	33	31
Minimum-Maximum	18–68	17–65
Country of birth		
Guatemala	167 (42)	114 (34)
Mexico	167 (42)	204 (60)
United States	13 (3)	4 (1)
Other	55 (14)	17 (5)
Recruitment site		
1	150 (37)	59 (17)
2	116 (29)	159 (47)
3	136 (34)	121 (36)
Sex		
Female	172 (43)	146 (43)
Male	230 (57)	193 (57)
Cigarette use		
Smoking status		
Current smoker	42 (10)	50 (15)
Former smoker	68 (17)	47 (14)
Lifetime nonsmoker	292 (73)	242 (71)
Work related		
Other inhalation exposures		
No	196 (49)	89 (26)
Yes	206 (51)	250 (74)
Respirator or dust mask use at work		
None of the time	312 (78)	164 (48)
Some of the time	35 (9)	74 (22)
Most of the time	4 (1)	11 (3)
All of the time	44 (11)	21 (6)
Not reported	7 (2)	69 (20)

Values are provided as number (%) unless otherwise specified.

TABLE 2

Prevalence of Self-reported Nasal and Respiratory Symptoms and Conditions in the Poultry Processing (n = 402) and Comparison (n = 339) Populations

	Poultry Processing Population, No. (%)	Comparison Population, No. (%)
Lifetime history		
Allergies	102 (25)	104 (31)
Asthma, not doctor diagnosed	2 (<1)	3 (1)
Asthma, doctor diagnosed	8 (2)	6 (2)
Wheezing or whistling in the chest	31 (8)	36 (11)
In the last 12 months		
Nasal symptoms	100 (25)	97 (29)
Wheezing or whistling in the chest	31 (8)	34 (10)
Wheezing or whistling in the chest after physical exertion	11 (3)	16 (5)
Wheezing or whistling in the chest in the absence of a cold	12 (3)	15 (4)
Woke with a feeling of tightness in the chest	22 (5)	17 (5)
Awoken by an attack of shortness of breath	21 (5)	18 (5)
Awoken by an attack of coughing	36 (9)	40 (12)
Sought medical care for breathing problems	8 (2)	9 (3)
In the last month		
Wheezing or whistling in the chest	24 (6)	17 (5)
Currently		
Taking medication for breathing problems	15 (4)	9 (3)
Breathing problems worsen at work	10 (2)	15 (4)

TABLE 3

The Prevalence and Associations of Nasal Symptoms and Current Asthma With Poultry Processing Work

		Nasal Symptoms*		Current Asthma	
	No.	**No. (%)**	**OR (95% CI)†**	**No. (%)**	**OR (95% CI)‡**
Comparison population	339	97 (29)	1.00	33 (10)	1.00
Poultry processing population	402	100 (25)	0.91 (0.59, 1.40)	35 (9)	0.96 (0.57, 1.62)
Poultry processing activities§					
Receiving, hanging, killing, plucking	48	17 (35)	1.04 (0.52, 2.08)	4 (8)	1.01 (0.32, 3.16)
Cutting, evisceration	98	31 (32)	1.10 (0.61, 1.97)	12 (12)	1.50 (0.69, 3.27)
Wash-up	16	2 (13)	0.37 (0.08, 1.59)	0 (0)	–
Trimming	66	22 (33)	1.41 (0.68, 2.92)	6 (9)	1.07 (0.37, 3.07)
Deboning	81	11 (14)	0.61 (0.25, 1.47)	4 (5)	0.64 (0.19, 2.15)
Chilling, packing	107	36 (34)	1.57 (0.84, 2.91)	12 (11)	1.23 (0.56, 2.71)
Sanitation	48	12 (25)	0.82 (0.33, 2.02)	3 (6)	0.46 (0.11, 1.92)
Other	35	3 (9)	0.13 (0.04, 0.42)	1 (3)	0.31 (0.06, 1.68)
No. of activities reported					
1	317	66 (21)	0.75 (0.47, 1.19)	29 (9)	1.05 (0.59, 1.85)
2–5‖	85	34 (40)	1.57 (0.81, 3.03)	6 (7)	0.71 (0.28, 1.82)

CI indicates confidence intervals; OR, odds ratio.

* In the last 12 months.

† Adjusted for age and allergy history.

‡ Adjusted for age, allergy history, sex, smoking status, and other inhalation exposures.

§ The comparison population (n = 339) is the referent population for all models of associations between poultry processing activities and health outcomes.

‖ 85 participants reported 2 or more activities: 2 (n = 73, 18%), 3 (n = 10, 2%), 4 (n = 1, <1%), 5 (n = 1, <1%).

TABLE 4

Sex-Stratified Mean (With Standard Deviation) Lung Function Measurements and Adjusted Differences Among Participants in the Poultry Processing Population Compared to Participants in the Comparison Population

	No.	FEV_1 (mL)[†]	FEV_1% Predicted[‡]	FVC (mL)[†]	FVC% Predicted[‡]	FEV_1/FVC %[†]
Men						
Comparison population,[*] mean ± SD	122	3, 612 ± 602	97.2 ± 13.9	4, 382 ± 654	97.5 ± 12.9	82.4 ± 6.4
Poultry processing population, mean ± SD	155	3, 337 ± 590	94.2 ± 12.9	4, 087 ± 686	94.9 ± 12.2	81.7 ± 6.1
		− 89 (− 203, 25)[§]	− 2.7 (− 6.0, 0.6)	− 84 (− 220, 53)	− 2.0 (− 5.1, 1.1)	− 0.4 (− 1.8, 1.0)
Poultry processing activities						
Receiving, hanging, killing, plucking	31	− 81 (− 233, 71)	− 2.5 (− 7.0, 1.9)	− 130 (− 311, 52)	− 3.3 (− 7.6, 1.0)	0.7 (− 1.3, 2.6)
Cutting, evisceration	30	− 118 (− 286, 50)	− 4.1 (− 8.9, 0.6)	− 93 (− 290, 104)	− 1.3 (− 5.8, 3.2)	− 0.9 (− 3.1, 1.3)
Wash-up	4	− 50 (− 386, 286)	4.2 (− 11.1, 19.6)	− 96 (− 636, 443)	0.9 (− 15, 16.8)	1.3 (− 4.3, 6.9)
Trimming	12	− 237 (− 445, − 28)	− 3.6 (− 11.3, 4.1)	− 264 (− 529, 1)	− 3.9 (− 11.0, 3.2)	− 0.3 (− 4.1, 3.4)
Deboning	37	− 16 (− 212, 180)	− 2.3 (− 7.9, 3.2)	83 (− 152, 317)	1.6 (− 3.8, 7.0)	− 2.0 (− 4.2, 0.1)
Chilling, packing	36	− 67 (− 238, 104)	− 2.9 (− 8.0, 2.2)	− 53 (− 255, 149)	− 1.1 (− 6.0, 3.8)	− 0.5 (− 2.8, 1.7)
Sanitation	34	− 192 (− 353, − 31)	− 4.6 (− 9.1, − 0.1)	− 206 (− 421, 9)	− 4.6 (− 9.0, − 0.3)	− 0.5 (− 2.9, 2.0)
Other	13	155 (− 17, 326)	4.6 (0.4, 8.9)	137 (− 103, 377)	2.7 (− 2.1, 7.6)	1.0 (− 1.6, 3.7)
No. of activities reported						
1	121	− 79 (− 198, 41)	− 2.3 (− 5.8, 1.2)	− 75 (− 225, 71)	− 2.2 (− 5.5, 1.2)	− 0.2 (− 1.7, 1.3)
2–5	34	− 126 (− 288, 36)	− 4.2 (− 8.9, 0.5)	− 113 (− 293, 67)	− 1.3 (− 5.6, 2.9)	− 0.9 (− 3.1, 1.3)
Women						
Comparison Population,[*] mean ± SD	100	2, 771 ± 445	86.3 ± 10.4	3, 281 ± 526	84.4 ± 10.1	84.6 ± 5.1
Poultry Processing Population, mean ± SD	124	2, 612 ± 402	86.1 ± 10.3	3, 072 ± 465	82.2 ± 9.8	85.1 ± 5.0
		− 26 (− 110, 57)	0.3 (− 2.5, 3.0))	− 64 (− 170, 41)	− 2.0 (− 4.7, 0.7)	1.0 (− 0.4, 2.3)
Poultry processing activities						
Receiving, hanging, killing, plucking	3	− 80 (− 217, 58)	− 2.2 (− 6.5, 2.1)	76 (− 275, 428)	0.5 (− 10.7, 11.7)	− 4.5 (− 11.8, 2.9)
Cutting, evisceration	34	− 27 (− 136, 83)	0.1 (− 3.4, 3.7)	− 16 (− 141, 109)	0.1 (− 3.2, 3.4)	− 0.5 (− 2.2, 1.3)
Wash-up	7	12 (− 207, 231)	3.8 (− 5.1, 12.7)	− 130 (− 474, 214)	− 4.2 (− 13.5, 5.0)	4.6 (− 0.3, 9.5)
Trimming	34	− 14 (− 128, 99)	0.8 (− 2.9, 4.4)	− 15 (− 150, 121)	− 0.7 (− 4.2, 2.9)	0.0 (− 2.2, 2.3)
Deboning	21	− 65 (− 242, 112)	− 3.1 (− 8.5, 2.3)	− 55 (− 286, 175)	− 2.7 (− 7.9, 2.6)	− 0.5 (− 2.8, 1.8)
Chilling, packing	37	− 76 (− 197, 45)	− 0.6 (− 4.4, 3.2)	− 149 (− 311, 14)	− 4.8 (− 8.3, − 1.3)	1.7 (− 0.3, 3.7)

	No.	FEV_1 (mL)[†]	FEV_1% Predicted[‡]	FVC (mL)[†]	FVC% Predicted[‡]	FEV_1/FVC %[†]
Sanitation	1	–[‖]	–	–	–	–
Other	10	22 (− 188, 233)	1.8 (− 6.0, 9.7)	− 23 (− 263, 218)	0.4 (− 6.5, 7.4)	1.1 (− 1.8, 4.0)
No. of activities reported						
1	103	− 26 (− 114, 60)	0.0 (− 2.9, 2.8)	− 80 (− 190, 31)	− 2.7 (− 5.5, 0.2)	1.3 (− 0.1, 2.8)
2–3	21	− 24 (− 161, 112)	1.7 (− 2.6, 6.0)	5 (− 146, 157)	0.9 (− 3.0, 4.9)	− 0.8 (− 3.1, 1.5)

[*] Referent category.

[†] Differences (with 95% CI) are adjusted for age, age squared, allergy history, height, height squared, smoking status, and other inhalation exposures.

[‡] Differences (with 95% CI) are adjusted for allergy history, smoking status, and other inhalation exposures.

[§] Negative values indicate mean values (in mL) lower than the mean of the comparison population; positive differences indicated mean values higher than the mean of the comparison population. For example, the adjusted mean FEV_1 generated among men who reported receiving, hanging, killing, or plucking is 81 mL lower than that of the comparison population.

[‖] Not estimated.