ORIGINAL ARTICLE

Respiratory symptoms and lung function in poultry confinement workers in Western Canada

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OBJECTIVE: To determine whether poultry production methods impact respiratory health, and whether poultry farmers have more respiratory symptoms and lower lung function than comparison control groups.
DESIGN: Cross-sectional study.
SETTING: Provinces of Saskatchewan, Alberta and Manitoba during the winters of 1997 to 1999.
POPULATION: Three hundred three poultry workers, 241 grain farmers and 206 nonfarming control subjects were studied. Poultry workers were further classified according to the poultry housing type in which they worked, ie, workers who worked with poultry raised on the floor (floor-based operations), which included broiler/roaster, broiler/breeder and turkey operations (n=181), and workers who worked with poultry raised in a caged setting (cage-based operations), which included egg operations (n=122).
INTERVENTIONS: Subjects completed a respiratory health questionnaire, which included questions on the poultry operation and work habits, and participated in lung function testing.
MAIN RESULTS: Overall, this study indicated that poultry workers report greater prevalences of current and chronic respiratory symptoms than control populations, and that the type of production method (cage-based versus floor-based) appears to influence the prevalence of respiratory symptoms and lung function values. Workers from cage-based operations report greater prevalences of current cough and wheeze, as well as lower mean values for forced expiratory volume in the first second (FEV_1), forced expiratory flow at 25% to 75% of vital capacity (FEF_{25-75}) and FEV_1/FVC than workers from floor-based facilities. Workers from cage-based facilities also reported greater prevalences of current and chronic cough and phlegm, as well as significantly lower FEF_{25-75} and FEV_1/FVC values than nonfarming control subjects. Furthermore, grain farmers had lower FVC and FEV_1 values than nonfarmers.
CONCLUSIONS: The results suggest that the type of poultry production system (ie, floor- versus cage-based) appears to have an effect on the respiratory response of workers from these facilities. Further studies are required to understand the physiological mechanisms of respiratory dysfunction and the relationships concerning workplace exposure among poultry workers.

Key Words: *Grain farmers; Lung function; Nonfarmers; Poultry workers; Respiratory symptoms*

Troubles respiratoires et fonctionnement respiratoire chez des éleveurs de volaille en claustration dans l'Ouest canadien

OBJECTIFS : Vérifier si les méthodes de production d'élevage de volaille ont une incidence sur la santé respiratoire et déterminer si les éleveurs souffrent de plus de troubles respiratoires que les sujets témoins et présentent un fonctionnement respiratoire moindre.
TYPE D'ÉTUDE : Étude transversale.
MILIEU : Étude menée en Saskatchewan, en Alberta et au Manitoba, au cours des hivers de 1997 à 1999.
POPULATION : Ont participé à l'étude 303 éleveurs de volaille, 241 producteurs de céréales et 206 sujets témoins ne travaillant pas à la ferme. Le premier groupe de sujets a par la suite été subdivisé en fonction du type de poulailler dans lequel ils travaillaient, soit l'élevage de volaille au sol (poulet à griller et poulet à rôtir; poulet à griller et poulet d'élevage; dindon) (n=181) et l'élevage de volaille en cage (œufs) (n=122).
INTERVENTION : Les sujets ont rempli un questionnaire sur la santé respiratoire, qui comprenait des questions sur les méthodes d'élevage de volaille et les habitudes de travail, et ont été soumis à des épreuves d'exploration fonctionnelle respiratoire.
PRINCIPAUX RÉSULTATS : Dans l'ensemble, l'étude révèle une fréquence plus élevée de troubles respiratoires contemporains et chroniques chez les éleveurs de volaille que chez les sujets témoins; de plus, le type d'élevage (au sol par opposition à en cage) semble avoir une incidence sur la fréquence des troubles respiratoires et le fonctionnement respiratoire. Les ouvriers travaillant dans des fermes d'élevage en cage ont fait état d'une fréquence plus élevée de toux contemporaine et de wheezing et ils ont connu des valeurs moyennes aux épreuves fonctionnelles (VEMS [volume expiratoire maximal par seconde], DME_{25-75} [débit maximal expiratoire 25-75 %] et rapport VEMS/CVF [capacité vitale forcée]) plus faibles que celles des ouvriers travaillant dans des fermes d'élevage au sol. En outre, les premiers (élevage en cage) ont déclaré des taux plus élevés de toux contemporaine et chronique et de mucosité que les sujets témoins, et leurs résultats de DME_{25-75} et de VEMS/CVF se sont révélés significativement plus faibles. Enfin, les producteurs de céréales ont obtenu des résultats de CVF et de VEMS plus faibles que les sujets ne travaillant pas à la ferme et les ouvriers travaillant dans des fermes d'élevage au sol.
CONCLUSION : Les résultats semblent indiquer que le type d'élevage de volaille (au sol par opposition à en cage) a une incidence sur la santé respiratoire des travailleurs. Il faudrait mener d'autres études pour mieux comprendre les mécanismes physiologiques du dysfonctionnement respiratoire et les liens entre le milieu de travail et les éleveurs de volaille.

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Poultry and egg production in Canada is a large industry, with 5000 commercial producers of eggs and poultry (1999 estimate) (1). Poultry workers spend considerable periods of time in their work environments, with atmospheric contaminants in these confinement units containing various levels of dusts, endotoxin, ammonia, hydrogen sulphide, and particles from feathers, skin, feed and litter (2,3). Repeated, long term exposure to these contaminants may put poultry workers at risk for developing respiratory dysfunction. Studies from other countries have reported respiratory effects related to working with poultry (4,5). Stewart et al (6) reported lower mean values for forced expiratory volume in the first second (FEV_1), as well as higher prevalences of cough, shortness of breath and chronic bronchitis in chicken farmers than in control subjects in the United States. Presence of respiratory and other symptoms was observed among poultry workers in a study conducted in Sweden (7). A study from Israel found that workers may develop occupational asthma from working in poultry confinement units (8). Morris et al (9) reported work-related respiratory symptoms, including increased chronic phlegm and wheezing and decreased mean values of FEV_1, over a work shift in chicken catchers compared with nonexposed blue-collar workers. Hagmar et al (10) of Sweden described symptoms of cough and nasal irritation after a work shift, and over shift decreases in forced vital capacity (FVC) and FEV_1 in poultry slaughterhouse workers.

In the present study, we report the results of a cross-sectional study conducted to examine the respiratory health of workers in the poultry industry in Western Canada. The objectives were to determine whether poultry production methods (cage- versus floor-based) impacts respiratory health, and whether poultry farmers have more respiratory symptoms and lower lung function values than comparison control groups.

METHODS

The committees on human research from the Universities of Saskatchewan, Manitoba and Alberta approved the study and informed consent forms. Informed consent was obtained from each subject before data collection. A cross-sectional study of poultry workers and comparison groups of grain farmers and rural-dwelling nonfarmers was conducted in the provinces of Saskatchewan, Alberta and Manitoba during the winter months of October to April from 1997 to 1999.

Study population

In total, 122 workers from caged-based poultry operations, 181 workers from floor-based operations, 21 workers from mixed poultry operations, 206 nonfarming control subjects and 241 grain farming control subjects participated in the study. A poultry worker was defined to be any person working a minimum of 2 h daily in a poultry confinement building in which at least 1000 poultry were resident at any one time throughout the year. None of the subjects raised more than 10 cattle or hogs. A list of registered poultry producers was obtained from each of the poultry marketing boards in the provinces of Saskatchewan, Alberta and Manitoba. All producers in the three provinces were mailed a personal letter and invited to participate (n=1163). Two hundred forty poultry operations with a total of 342 workers agreed to participate in the study; 324 of these workers were tested. Nonfarming controls were recruited using the health insurance registration files of the provincial health departments in Saskatchewan and Manitoba, and through a contract agency in Alberta. Grain farmers were identified using grain producers' lists for Western Canada. A random sample of grain farmers from each of the three provinces was invited to participate in the study. A control group of grain farmers was included in the study because most of the poultry producers also grew grain. Those who agreed to participate returned a reply card that included their name, age, sex and address. Caged- and floor-based poultry workers were matched by sex and age (within five years) to nonfarming and grain farming control subjects who resided within a 100 km radius of the matched poultry workers.

Questionnaire

Questionnaires were administered and pulmonary function tests were conducted on-site on the day of testing. A previously developed and piloted questionnaire was used in this study. The questionnaire was comprised of general respiratory health questions modified from the American Thoracic Society standardized questionnaire (11), as well as questions on poultry production operations, normal hours of work, years in the industry, occupational exposure history and acute symptoms related to work exposures. Chronic symptoms were identified as those occurring for at least three consecutive months out of the year. Current symptoms were identified as symptoms that were currently occurring but not of a chronic duration. A technician administered the questionnaire to each poultry worker, grain farmer and nonfarming control subject. Technicians were trained in questionnaire administration before beginning the study.

Pulmonary function tests

Spirographic variables of FEV_1, FVC, forced expiratory flow at 25% to 75% of vital capacity (FEF_{25-75}) and FEV_1/FVC ratio were measured by volume displacement using a Sensormedics dry rolling seal spirometer (Model 922, Sensormedics, USA). Measurements were made according to the standards of the American Thoracic Society (11). Reference values were obtained using the regression equations of Crapo et al (12). All measurements were made in the sitting position with a nose clip in place. When possible, baseline tests were completed on subjects before beginning work for the day. Because these tests were conducted off the work site, there is a potential that premeasurement acute exposure may have occurred in some subjects. There was a minimum of one-half hour since last poultry exposure to baseline pulmonary function testing. Technicians from the three provinces were trained in spirometry at the Centre for Agricultural Medicine (Saskatoon, Saskatchewan) prior to the study.

Statistical analysis

Means and standard deviations were used to describe continuous variables, including age, height, weight, FVC, FEV_1, FEF_{25-75} and FEV_1/FVC. Categorical variables, including symptoms, were described using frequencies and percentages. The differences in the means of continuous variables between the study groups were tested using one-way analyses of variance and

TABLE 1
Distribution of poultry workers and controls by production type and province of residence

Worker type	Alberta (n [%])	Saskatchewan (n [%])	Manitoba (n [%])	Total (n [%])
Poultry workers				
Floor-based				
Breeder/roaster	82 (58.6)	28 (20.0)	30 (21.4)	140 (100.0)
Turkey	16 (39.0)	11 (26.8)	14 (34.1)	41 (100.0)
Caged-based				
Egg	26 (21.3)	34 (27.9)	62 (50.8)	122 (100.0)
Mixed	6 (28.6)	8 (38.1)	7 (33.3)	21 (100.0)
Grain farmers	85 (35.3)	83 (34.4)	73 (30.3)	241 (100.0)
Nonfarmers	105 (51.0)	63 (30.6)	38 (18.4)	206 (100.0)
Total	**320 (41.5)**	**227 (29.4)**	**224 (29.1)**	**771 (100.0)**

TABLE 2
Demographic characteristics of study groups

Worker type	Men (n [%])	Women (n [%])	Age in years (mean ± SD)	Height in cm (mean ± SD)	Weight in kg (mean ± SD)
Floor-based worker	155 (85.6)	26 (14.4)*	42.0±10.7†	175.4±7.8	85.2±14.4
Cage-based worker	104 (85.2)	18 (14.8)	44.6±10.7	174.2±8.9	84.8±14.9
Grain farmer	211 (87.6)	30 (12.4)‡	46.4±12.2	175.5±7.3	87.3±13.7
Nonfarmer	158 (76.7)	48 (23.3)	43.4±11.6	172.9±9.3	83.8±16.2
Total	**628 (83.7)**	**122 (16.3)**			

**P=0.028 for floor-based workers versus nonfarmers; †P=0.002 for floor-based workers versus grain farmers; ‡P=0.003 for grain farmers versus nonfarmers*

Scheffe tests for post hoc comparisons. Analyses of covariance were used to test differences in mean lung function values after adjusting for age, sex, height and smoking (13). Logistical regression analysis was used to test differences in current and chronic symptoms after adjusting for age, sex, height and smoking (14).

RESULTS

The distribution of poultry workers, grain workers and nonfarming control subjects is shown in Table 1. Poultry workers were classified as those who worked in floor-based operations and those who worked in caged-based operations. Twenty-one workers who worked in more than one type of poultry operation (mixed) were excluded from the analysis. The proportion of workers from floor-based poultry operations was greater in Alberta than in Saskatchewan and Manitoba, whereas the proportion of workers from cage-based operations was highest in Manitoba. This distribution reflects that there are more floor-based poultry operations and fewer cage-based poultry operations in Alberta than in Manitoba.

As shown in Table 2, there were more male than female poultry workers. Mean height and weight were similar among the study groups, with grain farmers being significantly older than the poultry workers from floor-based operations. Mean number of hours spent in the poultry barn per day did not differ between the two groups, with workers from cage-based operations spending 4.03±2.37 h/day and workers from floor-based operations spending 3.86±2.60 h/day in the barn. There was an annual geometric mean of 73,318 birds for floor operations and 12,740 birds for cage operations. As shown in Table 3, the proportions of current smokers among poultry workers from cage-based operations (10.7%), floor-based operations (12.7%) and grain farmers (11.2%) were significantly lower than among nonfarming control subjects (17.5%). Overall, there was a higher proportion of poultry workers who had never smoked than grain farmers and nonfarmers. The proportion of nonfarmers who were current or former smokers was higher than among the other study groups.

TABLE 3
Smoking habits among study groups*

Study group	Never smoked (n [%])	Current smoker (n [%])	Former smoker (n [%])
Floor-based poultry worker	124 (68.5)	23 (12.7)	34 (18.8)
Cage-based poultry worker	79 (64.8)	13 (10.7)	30 (24.6)
Grain farmer	144 (59.8)	27 (11.2)	70 (29.0)
Nonfarmer	97 (47.1)	36 (17.5)	73 (35.4)

**Significance from χ^2 tests with two degrees of freedom: P=0.05 floor-based poultry worker versus grain farmer; P<0.001 floor-based poultry worker versus nonfarmer; P=0.02 grain farmer versus nonfarmer; P=0.008 cage-based poultry worker versus nonfarmer*

The prevalence of current respiratory symptoms is shown in Figure 1. After controlling for age, sex and smoking, workers from caged-based poultry operations reported a significantly higher prevalence of current cough and wheeze than workers from floor-based poultry operations. Workers from cage-based poultry operations also reported a significantly higher prevalence of current cough than grain farmers, and a significantly higher prevalence of cough and phlegm than nonfarmers. Nonfarmers reported a significantly higher prevalence of wheeze than workers from floor-based poultry

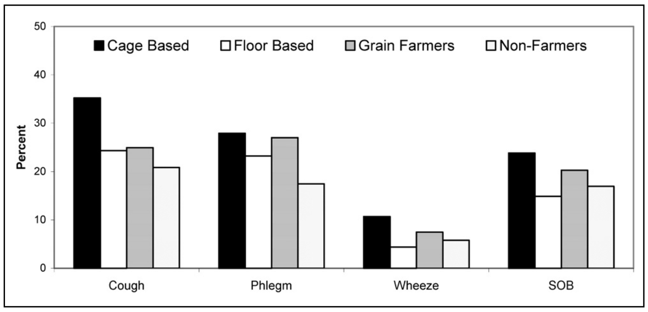

Figure 1) *Prevalence of current symptoms among study groups. After adjusting for age, sex and smoking, significant differences were observed between: floor-based and cage-based poultry workers for cough (P=0.024) and wheeze (P=0.03); floor-based poultry workers and nonfarmers for wheeze (P=0.034); cage-based poultry workers and grain farmers for cough (P=0.04); cage-based poultry workers and nonfarmers for cough (P=0.003) and phlegm (P=0.015); and grain farmers and nonfarmers for phlegm (P=0.014). SOB Shortness of breath*

TABLE 4
Adjusted mean lung function values (mean ± SE) for all study groups*

Study group	FVC (L)	FEV_1 (L)	FEV_1/FVC (%)	FEF_{25-75} (L/s)
Floor-based poultry workers	4.82±0.06	3.72±0.05†	77.25±0.60	3.42±0.10
Cage-based poultry workers	4.80±0.07	3.60±0.06‡	75.32±0.69§,¶	3.10±0.11**,††
Grain farmers	4.71±0.05‡‡	3.59±0.04§§	76.39±0.54	3.24±0.09
Nonfarmers	4.84±0.05	3.72±0.04	76.88±0.54	3.38±0.09

**Significant differences between groups were tested after adjusting for age, sex, smoking and height using analysis of covariance. †P=0.02 for floor-based poultry workers versus grain farmers; ‡P=0.03 for cage-based poultry workers versus floor-based poultry workers; §P=0.01 for cage-based poultry workers versus floor-based poultry workers; ¶P=0.06 for cage-based poultry workers versus nonfarmers; **P=0.01 for cage-based poultry workers versus floor-based poultry workers; ††P=0.03 for cage-based poultry workers versus nonfarmers; ‡‡P=0.05 for grain farmers versus nonfarmers; §§P=0.03 for grain farmers versus nonfarmers. FEF_{25-75} Forced expiratory flow at 25% to 75% of vital capacity; FEV_1 Forced expiratory volume in the first second; FVC Forced vital capacity*

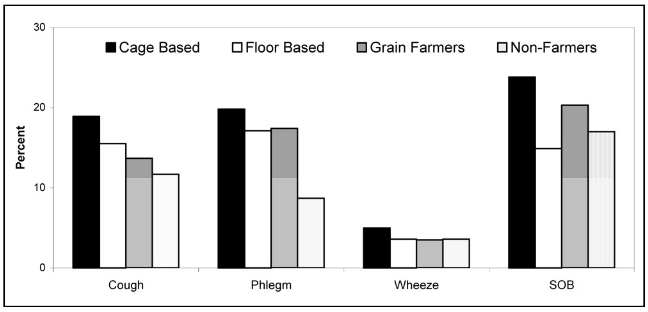

Figure 2) *Prevalence of chronic symptoms among study groups. After adjusting for age, sex and smoking, significant differences were observed between: cage-based poultry workers and nonfarmers for phlegm (P=0.004) and cough (P=0.04); floor-based poultry workers and nonfarmers for phlegm (P=0.003) and cough (P=0.06); and grain farmers and nonfarmers for phlegm (P=0.01). SOB Shortness of breath*

operations. Grain farmers reported a significantly higher prevalence of phlegm than nonfarming control subjects.

The prevalence of chronic respiratory symptoms is shown in Figure 2. After controlling for age, sex and smoking, chronic cough and phlegm were significantly more prevalent among workers from cage-based poultry operations than among nonfarming control subjects (cough 18.9% versus 11.7%, P=0.04; phlegm 19.8% versus 8.7%, P=0.004). In addition, workers from floor-based poultry operations also reported a significantly higher prevalence of cough and phlegm (cough 15.5%; phlegm 17.1%) than nonfarming control subjects (P=0.05 and P=0.003, respectively), as well as a significantly higher prevalence of eye irritation (14.0% versus 8.3%, P=0.003) than grain farmers. The prevalence of chronic phlegm in grain farmers (phlegm 17.4%) was significantly higher than it was in nonfarming control subjects (P=0.01). No significant differences were observed in chronic respiratory symptoms between workers from cage-based operations and workers from floor-based operations.

Reported allergies were highest in those who worked with caged poultry (22.1%); 16.0% of workers from floor-based operations reported an allergy. There were no reported allergies in the grain farming or nonfarming control groups. There was no significant difference in allergy reports between the two poultry groups.

After adjusting for age, sex, smoking and height, workers from cage-based poultry operations had significantly lower mean values for FEV_1, FEF_{25-75} and FEV_1/FVC than workers from floor-based operations, as well as significantly lower mean values for FEF_{25-75} and FEV_1/FVC than nonfarming control subjects (Table 4). Adjusted mean values of FVC and FEV_1 for grain farmers were significantly lower than those for nonfarming controls.

DISCUSSION

Our results have demonstrated a number of differences in both acute and chronic respiratory symptoms and lung function measures between poultry workers and control subjects. However, the most striking findings are the respiratory differences observed between workers in different poultry production operations (cage-based operations compared with floor-based poultry operations). Our findings indicate that different types of poultry production systems (ie, floor- versus cage-based) appear to have differing effects on the respiratory response in the workers from these facilities. In the present study, workers from cage-based poultry operations had lower mean values for FEV_1, FEV_1/FVC and FEF_{25-75}, as well as higher prevalences of current cough, phlegm, wheeze and shortness of breath than workers from floor-based poultry operations. It was also found that poultry workers in general (both floor- and cage-based) have increased prevalences of chronic cough and phlegm, and that those workers from cage-based poultry operations had lower values for FEF_{25-75} and FEV_1/FVC than the nonfarming control group. The increased prevalence of symptoms and the difference in pulmonary function between the two poultry groups indicate the possibility of a work-related respiratory insult. One should be cautious in generalizing these results, because a self-selection bias cannot be ruled out for these populations.

Similar respiratory effects, but to a much greater degree, have been identified in swine confinement workers; in this environment, contaminants are similar, although at differing levels than found in the poultry production industry (15-17). Dust, ammonia and endotoxin appear to be the primary environmental contaminants present in this work atmosphere that may be related to respiratory effects experienced by these workers (18-29). A dose-response relationship between across-shift changes in lung function and dust and ammonia levels was recently reported for poultry workers (28). Inhaled Inhaled Gram-negative bacteria or their endotoxin, as another airborne contaminant in poultry facilities, has the potential to alter lung function (29). We have previously shown that among men exposed to airborne contaminants in the swine industry, respiratory health measures relate most strongly to endotoxin exposures in the presence of low dust levels (30). The findings suggest the possibility that the differences in symptoms and lung function values between workers from the cage-based facilities and the floor-based facilities could be related to the different endotoxin levels in the two environments. Other factors that may relate to different exposures, and therefore different respiratory effects, for workers engaged in cage-based and floor-based poultry production that have yet to be elucidated include bird age, length of bird housing, particle size of dust, and work patterns and activities.

Several studies have indicated that working in poultry confinement units can elicit a significant respiratory response compared with other agricultural and nonagricultural occupations, and the data reported in the present study support these findings (2-10,28,29). Simpson et al (31) described results from nine different industries, in which the highest prevalences of work-related lower respiratory tract symptoms (38%), upper respiratory tract symptoms (45%) and chronic bronchitis (15%) were found in poultry workers. Rees et al (32) had similar results regarding work-related cough (32%) and wheeze (23%) in poultry workers. Leistikow et al (33) observed adverse symptoms of cough, phlegm, chest tightness and burning or watering eyes in egg farm workers. The respiratory response in poultry workers appears to be directionally similar to that observed in swine confinement workers (16,34).

The principal contaminants in poultry facilities include dust, endotoxin and ammonia, which vary widely and may be dependent on bird age, ventilation rates, work activities, housing type and other factors present at the work site (21). Donham et al (28) related exposure levels in poultry facilities to across-shift declines in lung function in exposed workers, and showed that significant functional decline was associated with 2.4 mg/m^3 of total dust, 0.16 mg/m^3 of respirable dust, 0.06 μg/m^3 of endotoxin and 12 ppm of ammonia. Studies have measured exposure levels in poultry facilities and have indicated that workers would generally be exposed to levels exceeding these thresholds (4,6,21-28).

Although the principal exposure patterns related to symptoms and reductions in lung function have not been fully delineated for the poultry industry, the literature suggests that type of production and housing may influence the level of contaminants present in the atmosphere, the resulting worker exposure and perhaps the effect on workers' respiratory health (35). This raises the possibility that the observed increased respiratory responses in poultry workers from cage-based operations compared with those from floor-based operations may be related to contaminant levels.

Our findings have certain limitations. First, the poultry producers were self selected, and we cannot rule out the possibility of self-selection bias with a response rate of 240 volunteers from a possible 1163 producers. Current and chronic symptoms were self reported by the workers based on the standardized American Thoracic Society questionnaire (11). Although we measured baseline lung function, we cannot exclude the possibility that the measurements may be sensitive to time of day, learning effect and premeasurement respiratory exposures.

An interesting additional observation from these data is the demonstration of higher frequency of respiratory symptoms and lower mean lung function values among grain farmers than the nonfarming, rural-dwelling control population. Previous studies have made observations of a similar nature in grain farmers compared with control subjects not exposed to organic dust (15,36). For this reason, we included the two control populations of grain farmers and nonfarming, rural-dwelling subjects. Despite that 30.7% of the poultry producers in this study also grew grain, adjusting for current grain farming did not influence the respiratory relationships that we have found. Thus, these respiratory effects cannot be attributed to grain farming alone and we believe they are the result of workplace exposures.

Further studies are required to elucidate the differences in contaminant loads related to different poultry rearing strategies, including housing types, bird age and length of housing, as well as the associated effects on worker health in these environments.

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