

Recommendations for reducing the effect of grain dust on the lungs

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Abstract • Résumé

Objective: To assess the appropriateness of the current Canadian standards for exposure to grain dust in the workplace.

Options: The current permissible exposure limit of 10 mg of total grain dust per cubic metre of air (expressed as mg/m³) as an 8-hour time-weighted average exposure, or a lower permissible exposure limit.

Outcomes: Acute symptoms of grain-dust exposure, such as cough, phlegm production, wheezing and dyspnea, similar chronic symptoms, and spirometric deficits revealing obstructive or restrictive disease.

Evidence: Articles published from 1924 to December 1993 were identified from *Index Medicus* and the bibliographies of pertinent articles. Subsequent articles published from 1994 (when the recommendations were approved by the Canadian Thoracic Society Standards Committee) to June 1996 were retrieved through a search of MEDLINE, and modification of the recommendations was not found to be necessary. Studies of interest were those that linked measurements of total grain dust levels to the development of acute and chronic respiratory symptoms and changes in lung function in exposed workers. Papers on the effects of grain dust on workers in feed mills were not included because other nutrients such as animal products may have been added to the grain. Unpublished reports (e.g., to Labour Canada) were included as sources of information.

Values: A high value was placed on minimizing the biological harm that grain dust has on the lungs of grain workers.

Benefits, harms and costs: A permissible exposure limit of 5 mg/m³ would control the short-term effects of exposure to grain dust on workers. Evidence is insufficient to determine what level is needed to prevent long-term effects. The economic implications of implementing a lower permissible exposure limit have not been evaluated.

Recommendations: The current Canadian standards for grain-dust exposure should be reviewed by Labour Canada and the grain industry. A permissible exposure level of 5 mg/m³ is recommended to control short-term effects. Further measurements that link the levels of exposure to respiratory health effects in workers across Canada should be collected to establish an exposure-response relation and possible regional differences in the effects of grain dust.

Validation: There has been no external review of these recommendations. However, the American Conference of Governmental Industrial Hygienists has recommended an 8-hour average exposure limit of 4 mg/m³ for wheat, oats and barley.

Sponsor: The recommendations were approved by the Standards Committee of the Canadian Thoracic Society.

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Objectif : Évaluer si les normes canadiennes actuelles sur l'exposition aux poussières céréalières au travail conviennent.

Options : La limite d'exposition permmissible actuelle de 10 mg de poussières céréalières par mètre cube d'air (exprimée en mg/m³) comme exposition moyenne pondérée dans le temps sur 8 heures, ou une limite d'exposition permmissible plus faible.

Résultats : Symptômes aigus d'exposition aux poussières céréalières comme la toux, la production de mucosités, la respiration sifflante et la dyspnée, symptômes chroniques semblables et déficits spirométriques révélant une maladie obstructive ou restrictive.

Preuves : Recherche dans *Index Medicus* d'articles publiés entre 1924 et décembre 1993, et bibliographies des articles pertinents. On a extrait par recherche dans MEDLINE des articles subséquents publiés entre 1994 (lorsque le Comité des normes de la Société canadienne de thoracologie a approuvé les recommandations) et juin 1996 et l'on n'a pas jugé nécessaire de modifier les recommandations. Les études intéressantes étaient celles qui établissaient un lien entre la mesure des niveaux totaux de poussières céréalières et l'apparition de symptômes respiratoires aigus et chroniques et de changements des fonctions pulmonaires chez les travailleurs exposés. On n'a pas inclus de communications au sujet de l'effet des poussières céréalières sur les travailleurs des provenderies, parce que d'autres nutriments, tels des produits d'animaux, peuvent avoir été ajoutés au grain. On a inclus des rapports non publiés (p. ex., adressés à Travail Canada) comme sources d'information.

Valeurs : On a accordé une grande valeur à la réduction au minimum des préjudices biologiques que les poussières céréalières peuvent avoir sur les poumons des travailleurs des céréales.

Avantages, préjudices et coûts : Une limite d'exposition permmissible de 5 mg/m³ contrôlerait les effets à court terme de l'exposition aux poussières céréalières sur les travailleurs. Il n'y a pas suffisamment de preuves pour déterminer le niveau nécessaire afin de prévenir les effets à long terme. On n'a pas évalué les répercussions économiques de la mise en oeuvre d'une limite d'exposition permmissible plus basse.

Recommandations : Travail Canada et l'industrie céréalière devraient revoir les normes canadiennes actuelles sur l'exposition aux poussières céréalières. On recommande un niveau d'exposition permmissible de 5 mg/m³ pour contrôler les effets à court terme. Il faudrait recueillir d'autres mesures qui établissent un lien entre les taux d'exposition et les effets sur la santé respiratoire des travailleurs du Canada afin d'établir un lien entre l'exposition et la réaction, ainsi que des différences possibles entre les régions quant aux effets des poussières céréalières.

Validation : Ces recommandations n'ont pas été étudiées à l'extérieur. L'American Conference of Governmental Industrial Hygienists a toutefois recommandé une limite d'exposition moyenne sur 8 heures de 4 mg/m³ dans le cas du blé, de l'avoine et de l'orge.

Commanditaire : Les recommandations ont été approuvées par le Comité des normes de la Société canadienne de thoracologie.

In 1976 the Canadian Thoracic Society, the medical section of the Canadian Lung Association, appointed a task force to review the published evidence on the symptoms and lung function of workers exposed to grain dust. The task force concluded that research into the respiratory effects of grain dust was justified and should be encouraged (Canadian Lung Association task force report on the health of grain workers, 1978 [unpublished]). The studies available at that time, although often weak in design, suggested that grain dust had harmful biological effects when inhaled.

Shortly after, Labour Canada introduced a program to control dust in grain elevators and a health surveillance program for elevator workers. For 1978 Labour Canada adopted a permissible exposure limit (PEL) of 10 mg of total grain dust per cubic metre of air (expressed hereafter as mg/m³) as an 8-hour time-weighted average exposure. At that time about 30 000 workers in grain elevators, 15 500 workers in grain mills and 250 000 farmers were exposed to grain dust in Canada.¹ Subsequently, more data were collected from many studies,²⁻¹⁸ including those in Canada supported by the Na-

tional Health Research and Development Program, Health and Welfare Canada, and the health surveillance program of Labour Canada. That grain dust had health effects was apparent.^{19,20}

In 1991 the Canadian Thoracic Society Standards Committee appointed an ad hoc committee comprising experts in occupational and respiratory medicine. The ad hoc committee was asked to re-examine the current knowledge on the relation between exposure to grain dust and respiratory effects and to make recommendations on how to prevent such effects.

Literature review

Articles published from 1924 to December 1993 on the effects of grain dust on the respiratory tract of workers were identified from *Index Medicus* and published articles. The ad hoc committee focused on articles that reported a relation between grain dust levels and effects on workers exposed. Its conclusions and recommendations were accepted by the Canadian Thoracic Society Standards Committee in 1994. To determine whether subse-

quent studies would necessitate modification of the recommendations, a MEDLINE search was done using the terms "grain dust" and "lung" for articles published from 1994 to June 1996. The ad hoc committee did not find any conflicting evidence, and the pertinent papers from this search were added, where appropriate, to the original list of articles reviewed.

Studies were available that involved farmers, workers in small country and large terminal grain elevators and workers in flour and feed mills in various parts of Canada and several other countries. Those that addressed the effects of grain dust on workers in feed mills were excluded, because in feed mills other nutrients such as animal products may be added. In 1992 two members of the ad hoc committee published, independently, a review that summarized the literature on the impact of grain dust on respiratory health up to that date.²¹ They described an association between exposure to grain dust and respiratory symptoms and abnormal lung function and suggested that a reduction of the respiratory effects of grain dust would be achieved by decreasing exposure.

Evidence

There is good evidence, from cross-sectional studies,^{2-11,18} that exposure to high levels of grain dust may have harmful effects on the lungs of workers. These studies revealed that workers who were exposed had acute and chronic respiratory symptoms of cough, phlegm production, wheezing and dyspnea. Lung function tests revealed the presence of an abnormality that was predominantly an obstructive disorder, although in some studies an accompanying restrictive disorder was found. However, because the subjects underwent testing during work hours, the acute effects of exposure may have been responsible for the findings, and the cross-sectional studies were unable to confirm a link between exposure and chronic symptoms.

Studies of short-term changes in lung function involving workers exposed to varying amounts of grain dust over a shift or a number of work weeks showed spirometric deficits in both volume and flow.¹²⁻¹⁷ In one study a fall in the forced expiratory volume in 1 second (FEV₁) and an increase in airway responsiveness appeared within 1 week after exposure; the latter deficit persisted over 4 weeks.¹⁷ In another study, such short-term abnormalities were found to disappear when exposure stopped because of layoff.¹² The transient effect was supported by evidence of poorer lung function in grain elevator workers, who had more regular exposure to grain dust, than in dockers, who had more intermittent exposure.²² In laboratory challenges, a temporary obstructive disorder was observed after exposure to grain dust.²³⁻²⁵

There were only a few long-term longitudinal studies published.²⁶⁻³⁰ Three²⁶⁻²⁸ attempted to standardize the

time at which lung function was tested in order to minimize any differences due to acute effects; however, the Labour Canada studies^{29,30} could not do so. The importance of standardizing the time of testing was shown in a study that monitored the peak expiratory flow rate in grain workers.³¹

In the controlled studies,^{26,27} a greater fall in the FEV₁ per year was observed in the groups of grain workers than in the control populations chosen, but the difference was relatively small. A healthy worker effect has been observed in grain workers, which may lessen the detection of long-term loss in lung function.^{27,30} Symptoms and lung function abnormalities have been found in nonsmokers.⁶ Smoking, which has been common in grain elevator workers, adds an effect. Airflow obstruction has been found to develop at a rapid rate in some grain workers, and changes in lung function during short-term exposures have often also been demonstrated in these workers.³² A study involving retired grain workers in British Columbia suggested a permanent consequence from work exposure,³³ but a study involving retired grain workers in Thunder Bay, Ont., did not show this (Dr. Irvin Broder: Assessment of grain handlers before and after retirement for the presence of reversible adverse health effects. Report to the National Health Research and Development Program, Department of National Health and Welfare, 1986 [unpublished]).

Studies with objective measurements of exposure

The studies that linked objective measurements of grain dust levels to an effect in workers were particularly important. Their findings, described in brief here, enabled the ad hoc committee to recommend a lower PEL.

DoPico and associates¹⁴ found that workers in their study who were exposed to grain dust levels of 4 mg/m³ or higher during shifts had significantly more symptoms than those exposed to 2 mg/m³.

In a study involving workers at terminal grain elevators in Thunder Bay, Ont., Corey and collaborators¹⁵ recorded a negative individual dose-response curve for lung function and respirable grain dust level over a work week. Lung function was best on Monday, lowest on Wednesday (the day during which the mean grain dust level was 5.7 mg/m³) and recovered to some extent on Friday (the day during which exposure was lowest, at 3.6 mg/m³).

In studying the effects in workers over 4 weeks, James and colleagues¹⁷ found that they were significantly greater in workers exposed to more than 20 mg/m³ than in those exposed to less than 10 mg/m³.

Enarson and coworkers,³² in a study involving workers at terminal elevators in Vancouver, found that those who were losing lung function most rapidly were exposed to the highest levels of grain dust and none of them had been exposed to a level of less than 5 mg/m³.

One of the ad hoc committee members and a colleague reviewed the results of Labour Canada's environmental and medical surveillance program for workers in the grain industry (Drs. J.A. Dosman and H.H. McDuffie: Final programme evaluation report of the Environmental and Medical Surveillance Programme in the Grain Industry. Prepared for the Occupational Safety and Health Branch, Labour Canada, Ottawa, 1989 [unpublished]). Despite the drawbacks of the data yielded in this program, they concluded that negative health effects were detectable above an exposure level of 5 mg/m³.

Huy and associates²⁸ examined the effect of grain-dust exposure and change in lung function in a 15-year longitudinal study involving 454 grain workers in Vancouver. They divided the workers into three groups according to their mean exposure level: high (more than 9 mg/m³), intermediate (4 to 9 mg/m³) and low (less than 4 mg/m³). The workers in the high-exposure group had the greatest decrease in FEV₁ (34.1 mL per year); the decreases in FEV₁ in the intermediate- and low-exposure groups were 21.1 and 10.4 mL per year respectively. The differences between the groups could not be explained by past exposures in the elevators, which had been higher before the study started. The authors argued from these findings that grain dust levels should be kept below 4 mg/m³ to minimize chronic effects. However, the FEV₁ in a control group of civic workers was the same as that in the intermediate-exposure group and higher than that in the low-exposure group. These findings left the ad hoc committee uncertain as to the level of grain dust to recommend to prevent chronic effects.

A recent study from France has shown a dose-response relation between grain dust levels and chronic respiratory symptoms, but the data were insufficient to draw additional conclusions on safe levels.³⁴

Biological activity of grain dust

Many biological activities of grain dust and its constituents in the lungs have been demonstrated in vitro and in animal models. The effects include activation of the immune system,³⁵⁻⁴¹ histamine release^{42,43} and bronchitis.^{25,44} Recently, endotoxins have been found to play an important role in the harmful effects of grain dust.⁴⁵

IgE-mediated allergic reactions have been reported to various constituents of grain dust (rusts,⁴⁶ smuts,⁴⁷ storage mites,^{48,49} weevils^{50,51} and durum wheat⁵²). However, allergy does not explain the effects in the vast majority of workers studied. The low proportion of workers with atopy in the grain industry may be the result of the early quitting of these people from this industry.⁵³

Risk factors

People with atopy recruited to the grain industry are at risk for asthma and appear to select themselves out,

since rates of atopy are lower among grain workers than among workers in other jobs.^{3,5} People with asthma seem to avoid employment in grain elevators.⁵⁴ Evidence has been found for¹⁷ and against⁵⁵ a relation between airway hyperresponsiveness and exposure to grain dust. One study implicated⁵⁶ and another exonerated⁵⁷ inherited antiprotease deficiency in the development of abnormal lung function in grain workers. Apart from the additive effect of smoking, there are no identified risk factors that predict which workers are at risk for the harmful effects of grain dust.

Conclusions

In 1976 Labour Canada classified grain dust as a nuisance dust and set the PEL at 10 mg/m³. Given the strong evidence of its biological and clinical effects on the lungs, grain dust should no longer be considered just a nuisance dust. After reviewing the results of studies of known grain dust levels and their effect on lung function, we recommend that the current Canadian standards be re-examined. To control short-term effects, even if they may be only temporary, a PEL of 5 mg/m³ would seem advisable. The number of studies providing evidence of chronic impairment in grain workers at a PEL below 10 mg/m³ were insufficient to permit firm conclusions about this aspect of exposure.

The grain industry has come a long way in improving grain dust levels in elevators, and most elevators comply well with the PEL of 10 mg/m³ set by Labour Canada. As of 1986, 70% of dust samples taken as part of Labour Canada's surveillance program revealed a PEL below 5 mg/m³ (Drs. J.A. Dosman and H.H. McDuffie: Final program evaluation report of the Environmental and Medical Surveillance Programme in the grain industry. Prepared for the Occupational Safety and Health Branch, Labour Canada, Ottawa, 1989 [unpublished]). In 1986 the American Conference of Governmental Industrial Hygienists recommended a PEL of 4 mg/m³ as an 8-hour time-weighted average for wheat, oats and barley, but this recommendation has not been implemented in the United States.⁵⁸

Recommendations

- The current Canadian standards for exposure to grain dust in the workplace should be reviewed by Labour Canada and the grain industry.
- To control short-term effects of grain dust the PEL should be lowered to 5 mg/m³; this decrease may not be necessary to prevent long-term effects.
- The Labour Canada surveillance program should be continued and every effort should be made to establish an exposure-response relation and possible regional differences in the effects of grain dust on workers.

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