ERJ Express. Published on November 21, 2007 as doi: 10.1183/09031936.00106407

October 1st, 2007

Respiratory effects of occupational exposures in a milk powder factory

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Short title: Respiratory effects in milk powder factory

Word counts:

Abstract: 198

Text: 3190

ABSTRACT

Ingestion of milk powder is a known cause of allergies in children, but the risks to respiratory health from exposure to inhaled milk powder have not been studied previously. The aim of this study was to assess the effects of occupational exposures in a milk powder factory on respiratory symptoms and lung function.

We conducted a cross-sectional study of 167 milk powder factory workers (response rate 77%) and 76 office workers (73%) from four factories in Thailand. All participants answered a questionnaire and performed spirometry. Measurements of concentrations of dust were used as additional information on exposures.

Mean respirable dust concentrations in the factory were 0.02–2.18 mg/m^3. Adjusted OR of breathlessness (OR 3.05, 95% CI 1.21-7.69) and nasal symptoms (2.57, 1.06-6.22) were significantly increased in production and packing staff. The OR of skin symptoms (4.48, 1.36-14.75) was significantly increased in those adding vitamin mixture to milk powder. Factory workers had significantly lower FEV1 % of predicted (-4.23, -7.70--0.76).

This study provided new evidence that workers exposed to milk powder by inhalation are at increased risk of nasal symptoms, wheezing and breathlessness, and have reduced spirometric lung function, even in relatively low air concentrations of milk dust.

Key words:

Lung function, milk powder, natural rubber latex, respiratory symptoms

INTRODUCTION

Ingestion of cow milk is a known cause of allergies, especially in children [1-3], but potential risks to respiratory health from inhaling milk powder have not been studied previously. To address this question we studied workers of a factory producing cow milk powder in Thailand. The milk powder is used as nutrition for babies and children after mixing with water. Since exposure control procedures are generally strict in food processing industry [4, 5], any respiratory effects seen in this population might have relevance for other occupational groups that can be exposed to milk powder in less controlled conditions, such as nurses in paediatric care, nannies and bakers.

The milk powder factory had several departments that were located in different areas separated from each other by walls, including office, production area, vitamin addition area, quality control area and packing area. The factory had in general emphasis on good hygienic conditions and had installed local extractors and enclosed some of the processes. The processes in the factory are presented in figure 1.

The objective of the study was to assess the relations of occupational exposures in milk powder factory workers to respiratory symptoms and spirometric lung function.

METHODS

Study design

A cross-sectional study was performed in September 2006-January 2007 among all workers in a milk powder factory and among office workers from altogether four factories in Thailand. All participants answered an interviewer-administered questionnaire and performed spirometry. The study was approved by the ethics committee of the Mahidol University, Thailand. All participants signed informed consent before participating.

Study population

Of a total of 245 workers in the milk powder factory, 167 workers (response rate 77%) participated in the study. These included 130 production and packing workers, 22 workers adding vitamin mixture, and 15 quality control staff members. Altogether 76 office workers (response rate 73%) from four factories formed the unexposed reference population, including 24 office workers from the milk powder factory, 18 from a microfibre factory, 18 from a wood furniture factory and 16 from a tile factory. Office workers were managers, other administrative staff, chauffeurs, and security staff checking identification batches at the gate.

Measurement methods

Questionnaire

A questionnaire on respiratory health, occupational exposures and lifestyle factors was modified from the Finnish Environmental and Asthma Study [6-13]. The questionnaire inquired about job history and specific exposures in current and past jobs. The questionnaire was translated into Thai and then back-translated into English to ensure the validity of translation.

Spirometry

Participants performed spirometry according to the standards by the American Thoracic Society [14] with a Minato Autospiro PAL spirometer (Minato Medical Sciences Ltd, Japan). The best forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) out of a minimum of three acceptable forced expirations were used as outcomes. Predicted values calculated from Thai population [15] were used to calculate FEV1 and FVC as percent (%) of predicted.

Outcome assessment

The outcomes of interest included the occurrence of respiratory symptoms in the past 12 months and asthma ever and in the past 12 months based on questionnaire information. These were defined as:

Cough: recurrent or prolonged cough.

Phlegm production: recurrent or prolonged phlegm production.

Wheezing: wheezing or whistling of the chest.

Breathlessness: chest tightness or difficulty breathing.

Nasal symptoms: dryness, itching or smarting of nose, stuffy nose, runny nose or repeated sneezing.

Eye symptoms: dryness of eyes, itchy eyes, irritation or smarting of eyes, watering of eyes, or redness of eyes.

Skin symptoms: dryness or flaking of skin, itchy skin, irritation, smarting or redness of skin, sore or tender skin, or urticaria.

Current asthma: Asthma diagnosed by a physician in the past 12 months.

Asthma ever: Asthma diagnosed by a physician ever during lifetime.

Lung function outcomes included FEV1, FVC, FEV1 %predicted and FVC %predicted based on the best values of FEV1 and FVC in spirometry.

Exposure assessment

Occupational exposures in the milk powder factory were the exposures of interest. First, exposure was assessed based on whether the subject was a factory worker (coded 1) or office worker (coded 0). Second, exposure among factory workers was assessed based on their job tasks and location of work area, classified into 3 groups: production line and packing staff, staff adding vitamins, and quality control staff. Production line staff had exposure to milk powder. Staff adding vitamin mixture and packing staff had also exposure to a mixture of vitamins, minerals and corn syrup. In addition, vitamin adding staff and quality control staff had exposure to natural rubber latex (NRL). Staff responsible for quality control of the milk powder had exposure to many other chemicals. We formed indicator variables for the three job categories (coded 1 if the participant belonged to the job category in question, 0 if not), while the office workers formed the common reference category. Third, exposure was assessed based on reported exposure to specific substances given in a list in the questionnaire. The most commonly reported specific exposures were milk (60%) and NRL (27%). Quality control staff reported exposure to several chemicals, including sulphuric acid (0.6 %), ethanol (6.6%), methanol (1.2%), sodium hydroxide (3.6%), and ammonium hydroxide (1.8%). Because of the small numbers for these specific exposures, we investigated separately only exposure to milk (yes=1, no=0) and NRL (yes=1, no=0), adjusted for each other in regression models. In addition, the specific exposures were categorized into sensitisers and irritants. Sensitisers included milk powder, welding fumes, cutting oils, NRL, tetrahydrofuran, and glues. Irritants included sulphuric acid, urea, sodium hydroxide, ammonium hydroxide, ethylacetate, ethanol, methanol, nitric acid, acetic acid glacial, acetone, thinner, microfibres, solvents, paints, acetronitrite and hexane.

Additional information on exposures was provided by annual measurements of dust and chemicals in the air of the factory performed by an independent consulting company (one of the authors, Dr. Phanprasit is a member of the monitoring team). Results on these were available for us for the last three years (2003-2005). Respirable dust concentrations had been measured using the method by National Institute of Occupational Safety and Health (NIOSH) of United States (method number 0600) [16].

Data analysis

Odds ratio (OR) and 95% confidence interval (95% CI) was calculated to quantify the relation between exposure and outcome. A model was fitted for each respiratory symptom and asthma separately. Three types of exposure variables, described in the exposure assessment section, were fitted in different sets of models. All models adjusted as potential confounders, including sex, age ($\leq$ 25 years, 26–30 years, $\geq$31 years), educational level (primary/high school, vocational school/college, bachelor/higher university degree), parental atopy or asthma (yes, no), smoking status (current, ex, never), exposure to secondhand smoke (SHS) at home and/or at work (yes, no), and work stress (a lot/very much stress, some/a little/no stress) in multivariate logistic regression.

Multiple linear regression was used to analyse the effect of exposures on lung function. A separate model was fitted for each outcome, including FEV1, FVC, FEV1 %predicted, and FVC %predicted. Models on lung function levels adjusted for sex, age, height, educational level, smoking status, SHS exposure at home and/or at work, and parental atopy/asthma. FEV1% predicted and FVC % predicted were already controlled for sex, age and height in the prediction equations.

RESULTS

Characteristics and symptoms of the study population

The study population included 142 men and 101 women aged 18-60 years. Factory workers were more often men, younger, had a lower education, and were more often current smokers than the office workers (appendix 1). Multivariate analyses adjusted for all these and other variables shown in appendix 1.

Table 1 shows the occurrence of respiratory symptoms by working in different tasks in the factory or being an office worker. The number of quality control staff was so small (n=15) that they were excluded as a specific task group from the analyses. Factory workers experienced twice as much wheezing and breathlessness (24% and 33%) as office workers (12% and 16%, respectively). Staff adding vitamins to milk powder had high occurrence of eye (41%) and skin symptoms (46%).

Air measurements

Air concentrations of respirable dust, consisting mainly of milk powder, had been monitored in the factory during the preceding 3 years (2003-2005) by an independent consulting company (appendix 2). The mean concentrations ranged 0.02–2.18 mg/m^3. Packing areas showed the highest concentrations (up to 2.18 mg/m^3) and in 2005 the levels were above the action level of 50% of threshold limit value (TLV), which is 3 mg/m^3 for respirable dust. Concentrations above action level had been measured in some production areas, vitamin rooms and warehouse areas in 2004-2005. The concentrations of different chemicals in the quality control department were in general low (data not shown) and below 50% of TLV.

Factory work and respiratory symptoms and asthma

Table 2. shows ORs of respiratory symptoms and asthma in factory workers compared to office workers. The crude OR of wheezing (2.31, 95% CI 1.06-5.05) and breathlessness (2.58, 1.29-5.17) were significantly increased in factory workers, and remained increased after adjustment for confounders (1.74, 0.67-4.54, and 2.20, 0.92-5.28, respectively), although were no more statistically significant. The risk of nasal symptoms was significantly increased after adjustment for confounders (2.30, 1.00-5.29). The risk of ever asthma was high in factory workers (OR 2.26), but due to the small number of asthmatics in the study population the confidence interval was wide. There were no cases of current asthma among the office workers (forming the reference group), so we could not calculate OR for asthma diagnosed in the last year.

Table 2. also presents ORs comparing different job tasks in the factory to office work. Production and packing staff had significantly increased risk of breathlessness (3.05, 1.21-7.69) and nasal symptoms (2.57, 1.06-6.22). They also had increased risk of ever asthma (OR 10.38), but again, due to the small number of asthmatics the confidence interval was wide. Vitamin adding staff had significantly increased risk of skin symptoms (4.48, 1.36-14.75).

Factory work and lung function

As shown in table 3., factory workers had significantly lower FEV1 % of predicted (-4.23, 95% CI –7.70 to -0.76). No significant effects were detected on absolute levels of FEV1 or FVC. This probably means that predicted values control better for age and height than just adjusting for them in the regression model. Factory workers included more young men than office workers, which was reflected in higher mean lung function levels when not taking into account the predicted values. Vitamin adding staff had in general lower lung function, FVC% predicted being significantly reduced (-6.26%, -11.45 to -1.07).

Specific exposures and respiratory effects

Exposure to milk was related to significantly increased risk of nasal symptoms (2.35, 1.11–5.02), and the risks of wheezing, eye symptoms and asthma were also increased (table 4.). Exposure to NRL was related to increased risk of skin symptoms (OR 1.73, 95% CI 0.70-4.30) and breathlessness (1.73, 95% CI 0.73-4.10), but the confidence intervals were wide due to the small number of exposed subjects. When studying exposure to sensitisers, the ORs of phlegm production, wheezing, breathlessness, nasal symptoms, eye symptoms, skin symptoms and asthma were all increased in a consistent pattern, although only nasal symptoms reached statistical significance (OR 2.13, 95% CI 1.11-4.08). Exposure to irritants was not consistently related to respiratory symptoms.

Those exposed to milk had lower spirometric lung function, the effect being significant for FVC (-0.14, –0.26 to -0.01) and FVC %predicted (-4.81, -8.13 to -1.50) (table 5). Those with exposure to sensitisers had in general lower lung function levels, the effect being significant for FVC % predicted (-2.96, -5.79 to -0.13). No effect on lung function was seen in relation to exposure to irritants.

DISCUSSION

In our study of exposures in a milk powder factory, factory workers were at increased risk of experiencing wheezing, breathlessness and nasal symptoms compared to office workers. They also had increased risk of asthma (OR 2.26), but this was not statistically significant because only a few subjects had diagnosed asthma in the population. According to a Medline database search, this is the first study investigating the risks related to inhaling milk powder. Production and packing staff had significantly increased risk of breathlessness and nasal symptoms compared to office workers. Staff adding a vitamin mixture to milk powder had significantly increased risk of skin symptoms. Thus, the factory workers experienced symptoms that are typically related to hypersensitivity of airways (i.e. wheezing, breathlessness, nasal symptoms) or skin, whereas they had less irritant-type of symptoms (i.e. cough or phlegm production). Hypersensitivity-type of mechanism was also supported by the fact that the air concentrations of respirable dust (consisting mainly of milk powder) were in general rather low during the preceding 3-year period, although in 2004 and 2005 there were some areas with concentrations above the action level. Sensitising agents are known to be capable to inducing reactions even in low concentrations [17]. Milk powder contains milk proteins, including caseins, α-lactalbumin and β-lactoglobulin, which are high-molecular-weight compounds typically inducing IgE-mediated hypersensitivity reactions. However, as we did not do specific IgE measurements in this epidemiological study, our discussion on mechanisms remains speculative.

Exposure to sensitising agents showed a consistent pattern of increased risk of upper and lower respiratory symptoms, skin symptoms and asthma, while no such pattern was detected in relation to irritants. Milk was the most common specific exposure and seemed to be the major exposure underlying the respiratory symptoms and asthma. Exposure to NRL probably underlied the increased risk of skin symptoms, as the vitamin adding staff used protective gloves, while the other job groups (apart from the quality control staff) did not use them and did not show excess of skin symptoms.

Lung function showed a pattern compatible with the respiratory symptoms. Factory workers had significantly lower FEV1 % of predicted compared to office workers. Lung function impairment was seen in relation to exposure to sensitisers, but irritants did not seem to affect lung function much. Among sensitisers, exposure to milk was related to significantly reduced FVC and also lower FEV1 values.

Our results suggest that there is a need for surveillance of respiratory symptoms and spirometry in factories with milk powder in the air, even if good exposure control measures are in effect, as significant adverse effects were detected at relatively low concentrations of milk powder. These results also raise the question, whether other occupations with potential milk powder exposure, e.g. nurses in paediatric settings, nannies, bakers, and other workers in food industries should be investigated in relation to milk powder exposure by inhalation.

Our results on skin symptoms emphasise that food processing factories should be aware of health risks related to NRL gloves and apply preventive measures. Based on experience from health care workers, effective preventive measures include use of low protein, powder-free latex gloves or non-latex gloves [18-21].

Validity of results

Selection of the study population

We achieved a good response rate (77%) among milk powder factory workers and office workers (73%), which reduces the likelihood of selection bias. As the response rates were even higher for spirometry among both factory and office workers, we were able to compare the lung function levels of respondents to that of total population (appendix 3). There were no significant differences in lung function levels, so the participants were representative of the total population and there was no suggestion of any selection according to respiratory health status.

Outcome and exposure assessment

Outcome assessment was based on both symptom reporting and objective lung function measurements and these gave consistent results. Factory exposures, mainly exposure to milk powder, were related to asthma-type of symptoms, i.e. wheezing and breathlessness, but only a small number of study subjects had diagnosed asthma. This may be because workers are afraid that if they have diagnosed asthma they might lose their job and thus do not seek medical help for their symptoms. Another potential explanation is that those with a diagnosed disease have left the workforce because of their disease. If the latter type of healthy worker selection is influencing our risk estimates, we would underestimate the true risks.

Exposure assessment was based on a combination of approaches. We used job tasks and work areas to categorize the factory workers into different exposure groups, utilizing knowledge of exposures in these different tasks and areas in combination with measurements of air concentrations of milk dust from the preceding 3 years. We also asked about exposure to some specific agents and categorized them into sensitisers and irritants. We detected adverse effects of sensitisers on (objective) lung function level in addition to (subjective) symptoms, which reduces the likelihood of biased reporting of exposures. Any non-systematic error in exposure assessment would lead to underestimation of the true risks, as would a tendency to place symptomatic workers into low exposure job tasks. Thus, some underestimation in our effect estimates is possible.

Confounding

We collected extensive data on potential confounders in our questionnaire and controlled for these factors in the multivariate regression models to exclude them as potential explanations for our findings. The most important differences between office and factory workers were that office workers included more female and older workers. As these characteristics are usually related to greater prevalence of symptoms and lower lung function levels, any residual confounding would influence in the opposite direction to our findings (which showed significantly increased risk of symptoms and reduced lung function in the exposed factory workers), which gives further assurance that our results are not explained by confounding. The prevalence of current smoking was somewhat more common among factory workers and we adjusted for smoking habits. Office workers were somewhat heavier smokers than factory workers, so any residual confounding by the amount of smoking would influence in the opposite direction to our findings.

Synthesis with previous knowledge

In a Medline database search, we were not able to find any previous study assessing the risk of adverse respiratory effects related to inhalation of milk powder, but our results are consistent with four case reports of occupational asthma [22], one from exposure to lactalbumin in a chocolate candy worker [23] and another from the same protein in a bakery worker [24], one from exposure to casein sprayed while tanning leather [25] and another from sodium caseinate exposure in a delicatessen factory worker [26]. These articles reported also three cases of occupational rhinitis from milk proteins [23, 25]. Our finding on NRL exposure being related to skin symptoms is consistent with studies in health care workers [27] and dental workers [28, 29]. However, our study seems to be the first one investigating the health risks of this exposure in food processing industry.

CONCLUSIONS

This study provides new evidence that workers exposed to relatively low levels of milk powder by inhalation are at significantly increased risk of nasal symptoms, wheezing, and breathlessness, and have reduced spirometric lung function. Workers exposed to a vitamin mixture added to milk have also increased risk of skin symptoms, which is most likely related to their use of NRL gloves. Our study suggests that industrial workforces with milk powder exposure should have respiratory surveillance programs, even if good exposure control measures are in effect. Other workforces with potential milk powder exposure by inhalation, e.g. nannies and bakers, should be investigated for potential health effects. Food processing industries should pay attention to preventive measures concerning use of NRL gloves.

ACKNOWLEDGEMENT

The authors would like to thank Associate Professor Chalermchai Chaikittiporn for supporting the data collection in Thailand and Professor Tom Sorahan for his guidance in using SPSS program.

FUNDING

This study was supported by a grant from the Royal Thai Government.

STATEMENT OF INTERESTS

PS and MSJ declare no competing interests. WP has no other competing interests, except that she has received consulting fees from the milk powder company for conducting air monitoring.

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TABLE 1 Occurrence of respiratory symptoms and asthma in the study population by being an office or a factory worker

Symptoms / conditions	**Office workers** N = 76		**Factory workers**					
			All factory workers N = 167		**Production and packing staff** N = 130		**Vitamin adding staff** N = 22	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Prolonged cough	13	17.1	31	18.6	25	19.2	6	27.3
Phlegm production	24	32.4	69	41.3	55	42.3	9	40.9
Wheezing	9	12.0	40	24.0	33	25.4	5	22.7
Breathlessness	12	16.0	55	32.9	48	36.9	6	27.3
Nasal symptoms	21	28.0	59	35.8	47	36.2	9	40.9
Eye symptoms	23	30.3	55	33.1	38	30.0	9	40.9
Skin symptoms	23	30.7	42	25.1	29	22.3	10	45.5
Asthma ever	3	3.9	5	3.0	5	3.8	0	0
Current asthma	0	0	2	1.2	2	1.5	0	0

TABLE 2 Crude and adjusted odd ratio (OR) of respiratory symptoms and asthma in relation to factory work, and adjusted OR by the job task. Office workers formed the reference category (OR =1)

Symptoms / Diseases	**Factory workers**							
	All N = 167				**Production & packing staff** N = 130		**Vitamin adding staff** N = 22	
	Crude OR	**95% CI**	**Adjusted OR***	**95% CI**	**Adjusted OR [1]**	**95% CI**	**Adjusted OR [1]**	**95% CI**
Cough	1.11	0.54 - 2.25	0.82	0.31 – 2.17	0.86	0.32 - 2.34	1.24	0.33– 4.64
Phlegm	1.47	0.83 - 2.61	0.95	0.46 – 1.98	1.04	0.48 – 2.24	1.02	0.34 – 3.06
Wheezing	2.31	1.06 - 5.05	1.74	0.67 – 4.54	2.21	0.80 – 6.08	1.58	0.39 – 6.37
Breathlessness	2.58	1.29 - 5.17	2.20	0.92 – 5.28	3.05	1.21 – 7.69	1.59	0.45 – 5.55
Nasal	1.42	0.78 - 2.57	2.30	1.00 – 5.29	2.57	1.06 – 6.22	3.25	0.99 – 10.71
Eye	1.14	0.64 - 2.05	1.63	0.74 – 3.59	1.43	0.61 – 3.33	1.89	0.59 – 6.13
Skin	0.76	0.42 -1.39	1.39	0.63 – 3.05	1.40	0.59 – 3.32	4.48	1.36 – 14.75
Asthma ever	0.75	0.18 - 3.23	2.26	0.30 – 17.29	10.38	0.66–162.83	-[2]	-

[1] Adjusted to sex, age, education, parental atopy or asthma, smoking, exposure to SHS at work and/or at home, and work stress

[2]Could not be estimated due to a small number

TABLE 3 Effect of factory work on lung function in comparison to office work (office workers formed the reference category)

	Factory workers					
Lung function	**All** N = 167		**Production & packing staff** N = 130		**Vitamin adding staff** N = 22	
	β	**95% CI**	**β**	**95% CI**	**β**	**95% CI**
FEV1[1]	0.002	-0.12 to 0.13	0.03	-0.10 to 0.17	-0.03	-0.23 to 0.16
FVC[1]	0.01	-0.12 to 0.14	0.05	-0.08 to 0.19	-0.10	-0.30 to 0.10
FEV1 % predicted [2]	-4.23	-7.70 to –0.76	-3.71	-7.43 to 0.01	-5.64	-11.60 to 0.32
FVC % predicted [2]	-2.99	-6.07 to 0.07	-2.30	-5.54 to 0.93	- 6.26	-11.45 to -1.07

[1] Effect estimate adjusted for sex, age, height, education, parental atopy or asthma, smoking, and SHS exposure at work and/or at home
[2] Effect estimate adjusted for education, parental atopy or asthma, smoking, and SHS exposure at work and/or at home. The predicted values controlled for age and height. They were calculated separately for men and women.

TABLE 4 Adjusted odd ratio (OR) of respiratory symptoms and asthma in relation to specific exposures in the factory compared to office workers and unexposed factory workers (OR=1 in this reference category)

	Exposed to milk[1] N = 100		**Exposed to NRL**[2] N = 46		**Exposed to sensitizers**[3] N = 108		**Exposed to irritants**[4] N = 30	
Symptoms / Diseases	**OR**[5]	**95% CI**	**OR**[5]	**95% CI**	**OR**[5]	**95% CI**	**OR**[5]	**95% CI**
Cough	1.23	0.53 – 2.87	0.75	0.26 – 2.18	0.98	0.46 – 2.08	0.36	0.08 – 1.68
Phlegm	1.14	0.58 – 2.26	1.37	0.61 – 3.06	1.18	0.66 – 2.12	0.93	0.40 – 2.18
Wheeze	1.62	0.71 – 3.66	0.93	0.36 – 2.39	1.44	0.70 – 2.97	0.93	0.33 – 2.62
Breathlessness	1.10	0.52 – 2.35	1.73	0.73 – 4.10	1.36	0.72 – 2.59	1.28	0.50 – 3.23
Nasal	2.35	1.11 – 5.02	1.16	0.49 – 2.70	2.13	1.11 – 4.08	1.04	0.43 – 2.56
Eye	1.62	0.77 – 3.42	1.12	0.47 – 2.63	1.41	0.74 – 2.68	1.01	0.41 – 2.47
Skin	1.03	0.46 – 2.27	1.73	0.70 – 4.30	1.64	0.84 – 3.19	0.34	0.11 – 1.08
Asthma ever	2.41	0.33 -17.82	0.76	0.05 -10.77	2.36	0.38 – 14.64	-[6]	-

[1] Adjusted for NRL exposure
[2] Adjusted for milk powder exposure
[3] Adjusted for exposure to irritants
[4] Adjusted for exposure to sensitisers
[5] Adjusted for sex, age, education, parental atopy or asthma, smoking status, and SHS exposure at work and/or at home, and work stress
[6] OR could not be calculated due to too few subjects with asthma

TABLE 5 Effect of specific exposures in the factory on lung function compared to office workers and unexposed factory workers (reference category)

	Exposed to milk[3] N = 100		**Exposed to NRL**[4] N= 46		**Exposed to sensitisers**[5] N = 108		**Exposed to irritants**[6] N = 30	
	Β	**95% CI**	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**
FEV1[1]	-0.004	-0.16 to 0.07	0.11	-0.03 to 0.25	0.02	-0.08 to 0.12	-0.02	-0.17 to 0.13
FVC[1]	-0.14	-0.26 to -0.01	0.20	0.05 to 0.35	-0.03	-0.14 to 0.07	0.04	-0.11 to 0.19
FEV1 % predicted[2]	-3.25	-7.06 to 0.55	2.02	-2.69 to 6.74	-2.10	-5.33 to 1.13	0.47	-4.41 to 5.36
FVC % predicted[2]	-4.81	-8.13 to -1.50	4.04	-0.06 to 8.15	- 2.96	- 5.79 to -0.13	1.81	-2.48 to 6.09

[1] Effect estimates adjusted for sex, age, height, education, parental atopy or asthma, smoking, and SHS exposure at work and/or at home.
[2] Effect estimates adjusted for education, parental atopy or asthma, smoking, and SHS exposure at work and/or at home. The predicted values controlled for age and height. They were calculated separately for men and women.
[3] Adjusted for exposure to NRL
[4] Adjusted for exposure to milk dust
[5] Adjusted for exposure to irritants
[6] Adjusted for exposure to sensitisers

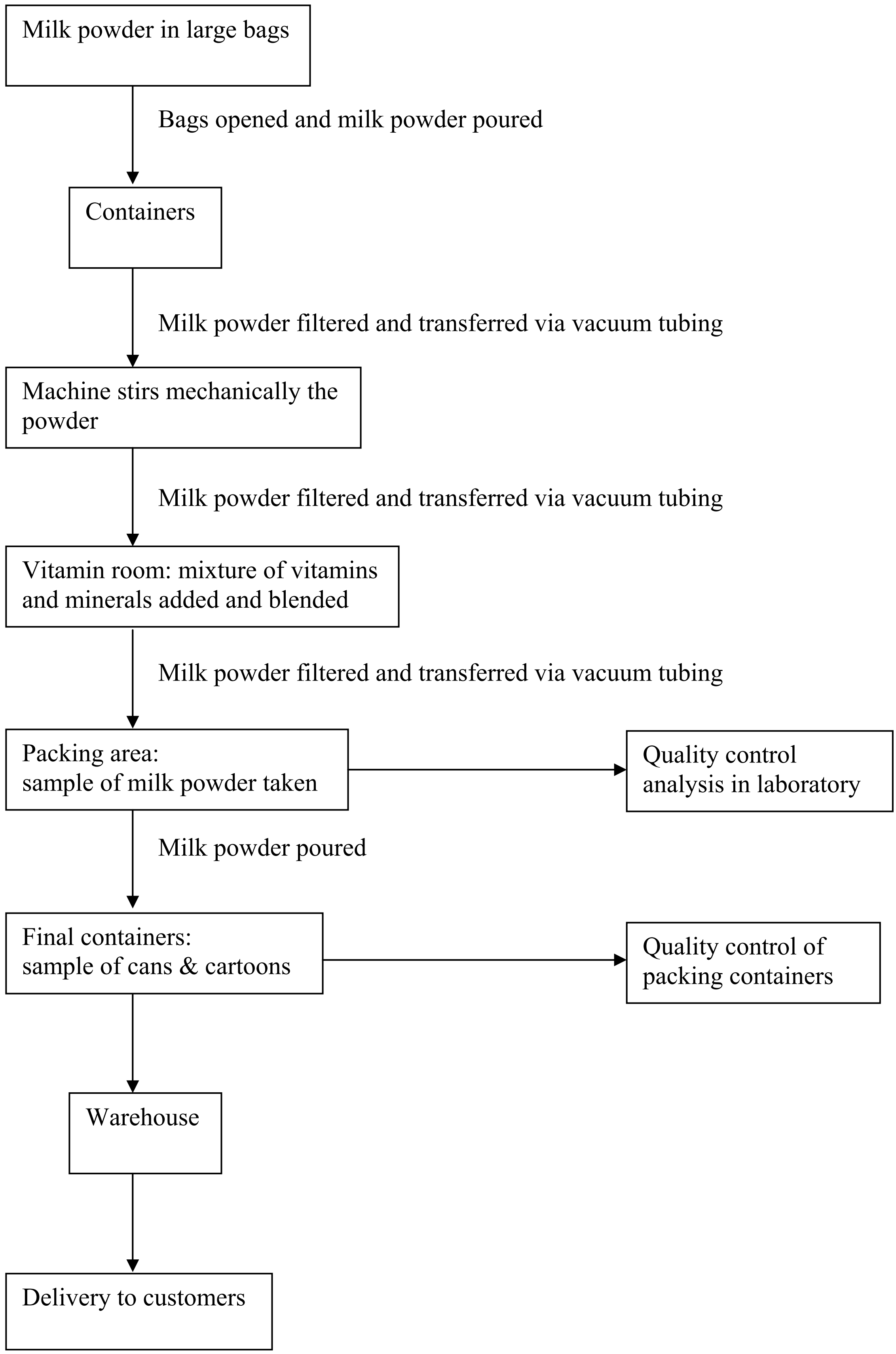

FIGURE 1. Processes taking place in the milk powder factory

APPENDIX 1. Characteristics of the total study population by being an office or a factory worker –for online-repository

	Office workers N = 76		Factory workers N = 167		Total N = 243	
	n	%	N	%	n	%
Sex						
Male	35	46.1	107	64.1	142	58.4
Female	41	53.9	60	35.9	101	41.6
Age						
≤ 25 years	9	11.8	96	57.5	105	43.2
26 – 30 years	15	19.7	48	28.7	63	25.9
≥ 31 years	52	68.4	23	13.8	75	30.9
Education						
Primary or high school	28	36.8	95	56.9	123	50.8
Vocational training or College	17	22.4	33	19.8	50	20.7
Bachelor or higher university degree	30	39.5	39	23.4	69	28.5
Smoking status						
Never	55	75.4	107	64.1	162	67.5
Past	5	6.8	14	8.4	19	7.9
Current	13	17.8	46	27.5	59	24.6
Secondhand smoke exposure at work and/or at home	32	42.1	107	64.1	139	57.2
Parental atopy/ asthma	15	19.7	23	13.8	38	15.6
Work stress	14	18.7	16	9.6	30	12.4

APPENDIX 2. Mean air concentrations of respirable dust by the work area in 2003-2005

Area	**Concentration of respirable dust (mg/m^3)**		
	2003	**2004**	**2005**
Production area 1	1.60	1.34	0.13
Production area 2	1.48	1.18	1.93[1]
Vitamin adding room 1	0.61	1.93*	1.60
Vitamin adding room 2	1.81	1.27	1.40
Vitamin adding area 3	N.A	N.A	1.49
Packing area1	1.34	1.08	1.33
Packing area 2	1.17	1.06	2.14 [1]
Packing area 3	1.13	0.85	2.18 [1]
Packing area 4	1.33	1.65[1]	N/A
Warehouse area 1	1.67	1.71[1]	1.42
Warehouse area 2	N/A	N/A	0.02

[1] mean concentration over the action level, which is 50% of TLV (TLV is 3 mg/m^3)

APPENDIX 3. Mean lung function level (± 1 SD) in those who answered the questionnaire compared to the total population, the results are given by being office worker or factory worker –for online repository

	Office workers			**Factory workers**		
	Answered questionnaire N = 73	**All office workers** N = 104	**p-value**	**Answered questionnaire** N = 167	**All factory workers** N = 218	**p-value**
FEV1 (l)	2.45 ± 0.49	2.49 ± 0.55	0.61	2.67 ± 0.57	2.72 ± 0.56	0.40
FVC (l)	2.68 ± 0.55	2.71 ± 0.63	0.73	2.87 ±0.63	2.92 ± 0.61	0.44
FEV1 %predicted	87.69 ± 11.72	87.33 ± 11.58	0.83	83.86 ± 12.09	84.50 ± 11.68	0.60
FVC %predicted	81.34 ± 10.85	80.58 ± 10.76	0.64	77.98 ± 10.50	78.35 ± 10.27	0.73