

ORIGINAL ARTICLE

# Asthma history, job type and job changes among US nurses

Orianne Dumas,<sup>1,2</sup> Raphaëlle Varraso,<sup>3,4</sup> Jan Paul Zock,<sup>5</sup> Paul K Henneberger,<sup>6</sup> Frank E Speizer,<sup>1</sup> Aleta S Wiley,<sup>1</sup> Nicole Le Moual,<sup>3,4</sup> Carlos A Camargo Jr<sup>1,2</sup>

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For numbered affiliations see end of article.

## Correspondence to

Dr Orianne Dumas, Channing Division of Network Medicine, Department of Medicine, Brigham & Women's Hospital, 181 Longwood Avenue, Boston, MA 02115, USA; [orianne.dumas@channing.harvard.edu](mailto:orianne.dumas@channing.harvard.edu)

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## ABSTRACT

**Objectives** Nurses are at increased risk of occupational asthma, an observation that may be related to disinfectants exposure. Whether asthma history influences job type or job changes among nurses is unknown. We investigated this issue in a large cohort of nurses.

**Methods** The Nurses' Health Study II is a prospective study of US female nurses enrolled in 1989 (ages 24–44 years). Job status and asthma were assessed in biennial (1989–2011) and asthma-specific questionnaires (1998, 2003). Associations between asthma history at baseline (diagnosis before 1989, n=5311) and job type at baseline were evaluated by multinomial logistic regression. The relations of asthma history and severity during follow-up to subsequent job changes were evaluated by Cox models.

**Results** The analytic cohort included 98 048 nurses. Compared with nurses in education/administration (likely low disinfectant exposure jobs), women with asthma history at baseline were less often employed in jobs with likely high disinfectant exposure, such as operating rooms (odds ratio 0.73 (95% CI 0.63 to 0.86)) and emergency room/inpatient units (0.89 (0.82 to 0.97)). During a 22-year follow-up, nurses with a baseline history of asthma were more likely to move to jobs with lower exposure to disinfectants (HR 1.13 (1.07 to 1.18)), especially among those with more severe asthma (HR for mild persistent: 1.13; moderate persistent 1.26; severe persistent: 1.50, compared with intermittent asthma, p trend: 0.004).

**Conclusions** Asthma history was associated with baseline job type and subsequent job changes among nurses. This may partly reflect avoidance of tasks involving disinfectant use, and may introduce bias in cross-sectional studies on disinfectant exposure and asthma in nurses.

## INTRODUCTION

Workplace exposures are recognised as an important risk factor for adult-onset asthma.<sup>1–2</sup> Occupational exposures may also cause exacerbation of a pre-existing asthma,<sup>3</sup> and are associated with a more severe and uncontrolled disease.<sup>4–6</sup> Healthcare workers account for a large part of work-related asthma cases in the USA<sup>7</sup> and other developed countries,<sup>8–10</sup> especially among women.<sup>11</sup> Among healthcare workers, nurses, nurse aides and cleaning workers have been identified as higher risk occupations for asthma.<sup>7–9–12–17</sup> These findings may be explained partly by

## What this paper adds

- Nurses are at increased risk of occupational asthma, an observation that may be related to exposure to disinfectants. Whether asthma history is associated with subsequent job type or job changes among nurses is unknown.
- In a prospective study of 98 048 US female nurses followed up over 22 years, women with a history of asthma were less often employed in nursing jobs likely to involve high disinfectant exposure at baseline, and they were more likely to move to jobs involving a lower level of exposure during follow-up.
- Our findings emphasise the importance of addressing healthy worker effect bias in epidemiological studies that aim to identify asthmagens in healthcare settings.

occupational exposures to cleaning and disinfecting products.<sup>18</sup> Studies have shown associations between cleaning products and disinfectants exposures and asthma onset,<sup>12–19–20</sup> severity, poor control and exacerbations,<sup>5–21–22</sup> particularly for nurses.<sup>13–23</sup> In addition, a Swedish cross-sectional study found that nurses and healthcare workers performing cleaning tasks are more likely to have respiratory-related absence from work than the general population.<sup>17</sup>

Many cleaning and disinfecting products have been identified as respiratory irritants or sensitizers.<sup>18</sup> Associations with asthma have been observed for some specific exposures (eg, quaternary ammonium compounds, ammonia, bleach, sprays),<sup>14–22–24</sup> but a better knowledge of the putative effects of specific substances is still needed.<sup>18–25</sup> Most existing studies are cross-sectional and subject—among other potential limitations—to a healthy worker effect bias.<sup>26</sup> Indeed, the potential tendency of workers with asthma to avoid or leave hazardous jobs may cause an underestimation of the associations between occupational exposures and asthma in cross-sectional studies.<sup>27</sup>

It has never been investigated whether asthma history influences job type or job changes among nurses and whether there is a possibility of a healthy worker effect bias in cross-sectional studies on disinfectant exposure and asthma. In the Nurses' Health Study II (NHSII), a large, ongoing, prospective study of US female nurses, we aimed to

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determine whether asthma history and asthma characteristics are associated with subsequent nursing job type and job changes over a 22-year period.

### METHODS

#### Population

The NHSII began in 1989 when 116 430 female registered nurses from 15 US states, aged 25–44 years, completed a mailed questionnaire on their medical history and lifestyle characteristics.<sup>28</sup> Every 2 years, follow-up questionnaires have been sent to update information on potential risk factors and identify newly diagnosed diseases. This investigation was approved by the Institutional Review Board at the Brigham and Women's Hospital, Boston, Massachusetts, USA.

#### Asthma

In all biennial questionnaires since 1991, the participants were asked if they had physician-diagnosed asthma, and if yes, when the diagnosis had occurred. Asthma history before baseline was defined by the report of physician-diagnosed asthma in 1991, with a date of diagnosis 'before September 1989' (figure 1).

Supplemental questionnaires on asthma were sent in 1998 and 2003, to all living women who had reported a physician diagnosis of asthma in earlier biennial questionnaire(s). More detailed information on dates of symptom onset and diagnosis, asthma symptoms, medications and hospitalisations for asthma were collected. Asthma cases were defined in 1998 and 2003 as participants who reiterated on the supplemental questionnaire that they had physician-diagnosed asthma, and reported using an asthma medication since diagnosis.<sup>28</sup> Age of diagnosis reported in supplemental asthma questionnaire was used to further classify nurses with a history of asthma according to age at asthma onset. In addition, asthma severity in 1998 and in 2003 was defined using a four-level (intermittent, mild persistent, moderate persistent and severe persistent) classification system<sup>16 29</sup> based on the 1997 US National Institutes of Health asthma guidelines.<sup>30</sup> According to current recommendations, this definition would reflect both asthma severity and control.<sup>16</sup> This classification was based on a question on days kept from work or usual activities within the past 12 months because of asthma; four questions on days per week (over the past 4 weeks) with: (1) 'wheeze or whistling sound in chest', (2) 'phlegm, sputum, or mucus from chest', (3) 'shortness of breath' and (4) 'cough'; and a question on 'breathing between asthma flares'. Women with asthma who reported having ever had hay fever, seasonal allergies or allergic rhinitis in the 1998 supplemental asthma questionnaire were classified as having 'allergic asthma'. Finally, latex allergy was evaluated in the biennial questionnaire in 2001.

#### Job type, job changes and use of disinfectants

Data on work status and type of nursing job were collected at baseline (1989) and in follow-up questionnaires in 1993, 1997, 2001, 2009 and 2011 with the question 'Which best describes your current employment status'. In 1989, options included nursing in the inpatient or emergency room (ER), operating room (OR), outpatient or community; nursing education; nursing administration; other nursing; non-nursing employment; or full-time homemaker. Other options were included in follow-up questionnaires (eg, intensive care unit (ICU), disabled, retired, other). For the current analyses, job types were regrouped into five categories: 'non-nursing job', 'education or administration nursing', 'outpatient nursing or other nurses', 'nursing in ER or inpatient units' (including ICU) and 'operating

room nursing'. In 2009 and 2011, general questions regarding the frequency (days/week) of use of disinfectants at work have been added ('Thinking about your current job and the use of disinfectants [such as ethylene oxide, hydrogen peroxide, ortho-phthalaldehyde, formaldehyde, glutaraldehyde and bleach]: (a) On how many days per week, on average, do you clean medical instruments with disinfectants? (b) On how many days per week, on average, do you clean surfaces (like floors, tables) at work with disinfectants?').

#### Statistical analyses

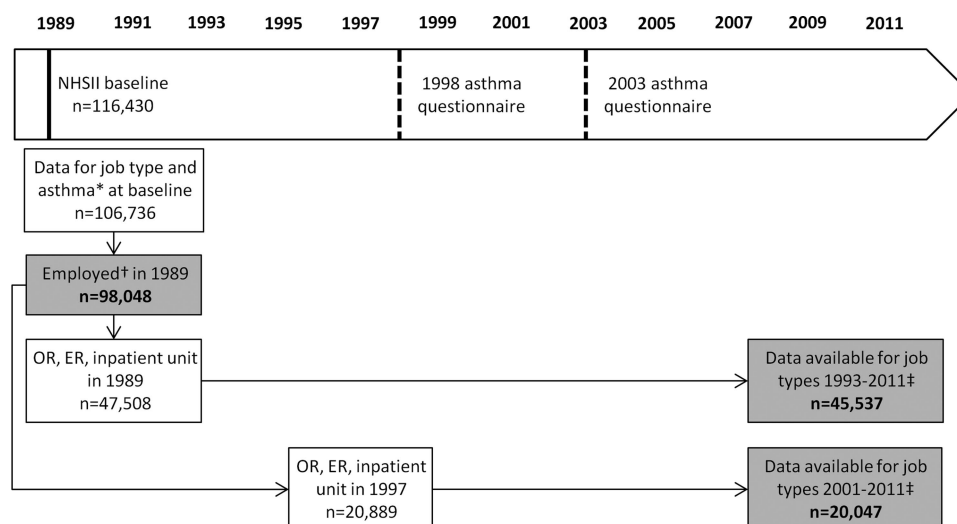
Associations between asthma history at baseline (diagnosis before 1989) and job type at baseline were evaluated by multinomial logistic regression. The association between asthma history and subsequent job changes over 1989–2011 was studied among nurses holding jobs with expected high disinfectant exposure at baseline, that is, nursing in OR, ER or inpatient units (figure 1). For this analysis, Cox proportional hazard models were used to study the event 'leave jobs with high exposure level' (ie, transfer to outpatient/community nursing, nursing education/administration or other nursing; non-nursing employment, full-time homemaker or retirement) versus 'stay in a job with high exposure level'. Time-to-event was defined as the time to 'definitive' transfer to a job with lower exposure level (ie, transfer to a job with lower exposure level was considered only if the nurse did not report a 'high exposure level job' in a subsequent questionnaire). Women were censored at the date of the last returned questionnaire with information on work status. Among women with asthma, associations between allergy status (assessed in 1998), latex allergy (assessed in 2001) and asthma severity (assessed in 1998 and/or in 2003) and subsequent job changes over 2001–2011 were studied among nurses holding jobs with expected high disinfectant exposure in 1997. Asthma severity was handled as a time-varying covariate in the Cox proportional hazard model.

In all analyses, potential confounders taken into account were age, race (white vs non-white), ethnicity (Hispanic vs non-Hispanic), smoking habits (non-smoker, ex-smoker or current smoker) and body mass index (BMI, <25, 25–29.9, ≥30 kg/m<sup>2</sup>). A two-sided p value <0.05 was considered statistically significant. All analyses were run using SAS V.9 (SAS Institute, Cary, North Carolina, USA).

#### RESULTS

A total of 106 736 women provided information on job type on the NHSII baseline questionnaire (1989), and completed the 1991 questionnaire (including, for the first time, a question on asthma). After excluding 8688 women who reported 'full-time homemaker' at baseline, the analytic cohort comprised of 98 048 women (figure 1).

A history of asthma at baseline was reported by 5311 participants (5%). Women with asthma at baseline were slightly older, more often overweight or obese, more often ex-smokers, and less often current smokers than nurses without asthma (table 1). Most participants reported working as nurses in the ER or inpatient unit (43%) or in outpatient/other nursing (34%) at baseline; other participants worked in nursing education/administration (13%), in the OR (5%) or in non-nursing employment (4%). Small but significant differences in job types in 1989 were observed according to the covariates: nurses in the ER or inpatient unit (mean age (SD) 33.3 (4.7) years) or in the OR (34.4 (4.5) years) were younger than nurses in education/administration (35.7 (4.3) years, p<0.001). They were also more often non-white (7% among nurses in the ER or inpatient unit;



**Figure 1** Flow chart of the population showing the different samples included in the analyses (shaded boxes), NHSII (ER, emergency room; NHSII, Nurses' Health Study II). \*The question on physician-diagnosed asthma and date of diagnosis was added for the first time in 1991. Asthma history at baseline was defined retrospectively by the report of physician-diagnosed asthma in 1991, with date of diagnosis 'before September 1989'. †Women unemployed in 1989 (excluded) were those who reported being a 'full-time homemaker'. They reported slightly less often asthma at baseline than employed women (4.9% vs 5.4%, adjusted  $p=0.07$ ). ‡Women who returned at least one questionnaire and provided data on job type over the studied period.

8% among OR nurses) than nurses in education/administration (6% non-white). Nurses in OR were less often overweight (19%) or obese (10%) than nurses in education/administration (20% overweight, 14% obese).

The frequency of disinfectant use was reported by participants for the first time in 2009, and there were clear differences in self-reported disinfectant use according to job type (figure 2). As expected, OR nurses reported the highest level of

disinfectant use, with weekly use of disinfectants to clean surfaces (70%) or to clean instruments (36%), compared with nurses in the ER or inpatient unit (52% and 30%, respectively) and to nurses in education/administration (13% and 4%).

### Asthma history and job type at baseline

Compared with education/administration nurses, women with asthma history were less often employed in the OR (odds ratio (95% CI) 0.73 (0.63 to 0.86), table 2) and in ER or inpatient units (0.89 (0.82 to 0.97)) at baseline. Similar results were observed in sensitivity analyses when a more stringent definition for asthma was used (ie, a case who reiterated having physician-diagnosed asthma in supplemental asthma questionnaires, with a consistent date of diagnosis), and when studying job type in 1993 instead of job type in 1989 (results not shown). Analyses stratified by age at baseline showed relatively consistent associations across age groups (see online supplementary table E1). Among OR nurses, with regard to age at asthma onset, an association of similar magnitude was observed with childhood-onset asthma (age at diagnosis <18 years, 0.72 (0.56–0.91)) and adult-onset asthma (age at diagnosis ≥18 years, 0.68 (0.53 to 0.87)). For nursing in ER or inpatient units, an association was observed only with childhood-onset asthma (0.78 (0.68 to 0.90)) but not with adult-onset asthma (0.97 (0.85 to 1.10)).

### Asthma history and characteristics, and subsequent job changes

The association between asthma history at baseline and job changes over 1989–2011 was studied in 45 537 nurses in OR, ER or inpatient units in 1989 (table 3). Transition to a job with a lower level of disinfectant exposure was observed in 68% of nurses without a history of asthma at baseline, and 71% of nurses with a history of asthma. In the multivariable-adjusted Cox proportional hazard model, nurses with asthma history had a significantly higher rate of transition to a job with lower exposure than nurses without asthma history (HR (95% CI) 1.13 (1.07 to 1.18)). The association between asthma and job changes was more pronounced in older women; the HR was

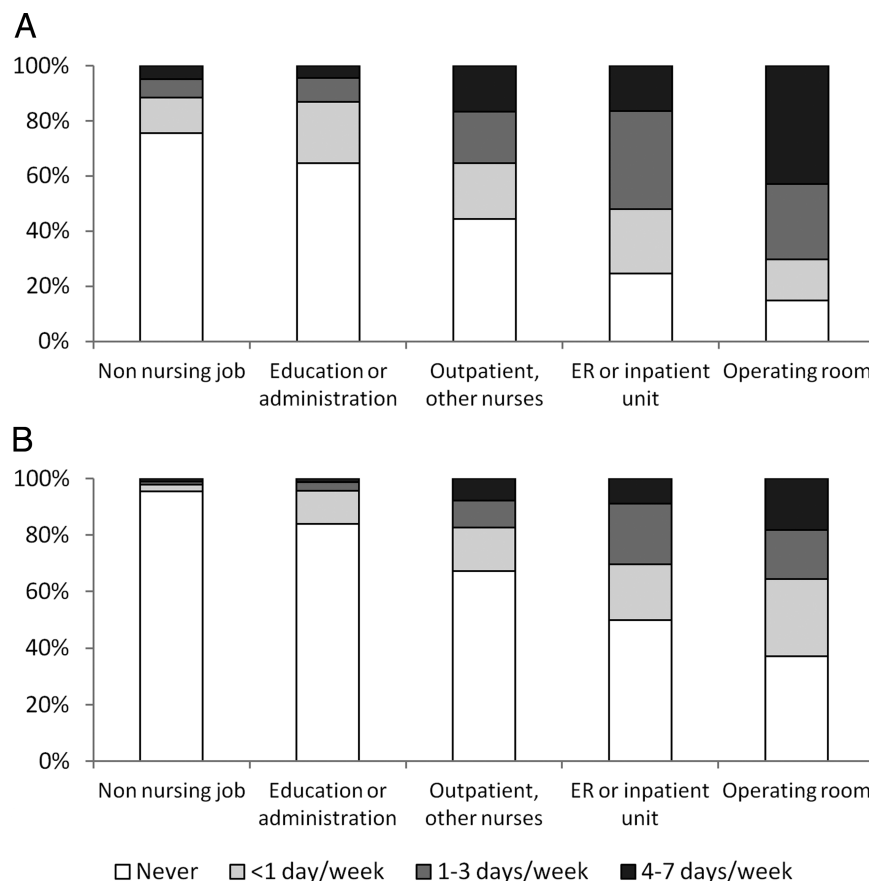
**Table 1** Sociodemographic characteristics according to asthma status at baseline, Nurses' Health Study II

	Asthma history before 1989		p Value
	No	Yes	
N	92 737	5311	
Age, mean (SD)	34.3 (4.7)	35.0 (4.6)	<0.001
Age group			
24–30	18.4	14.0	<0.001
30–35	31.9	30.6	
35–40	32.5	35.7	
40–44	17.2	19.8	
Race/ethnicity			
Non-white, %	7.1	7.0	0.73
Hispanic, %	1.8	2.1	0.16
Smoking habits, %			
Never-smoker	65.0	64.1	<0.001
Ex-smoker	21.1	24.5	
Current smoker	13.8	11.3	
Missing	0.1	0.1	
BMI (kg/m <sup>2</sup> ), %			
<25	69.5	60.7	<0.001
25–29.9	18.6	21.0	
≥30	11.3	17.6	
Missing	0.6	0.7	

BMI, body mass index.

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**Figure 2** Reported frequency of use of disinfectants to clean (A) surfaces (n=54 738) and (B) medical instruments (n=54 843), according to job type, in 2009, Nurses' Health Study II. The distribution of job types among participants employed in 2009 (n=55 301) was as follows: non-nursing job, 7%; education or administration nursing, 18%; outpatient or other nurses, 48%; ER or inpatient unit nursing, 23%; and operating room nursing, 5% (ER, emergency room).



1.04 (0.92 to 1.17) for those 24–29.9 years of age; 1.05 (0.96 to 1.15) for those 30–34.9 years of age; 1.24 (1.13 to 1.35) for those 35–39.9 years of age; and 1.21 (1.07 to 1.37) for those 40–44 years of age (*P* interaction 0.02). In addition, a stronger association was observed among women working in the OR at baseline (n=5043), with an HR of 1.25 (1.04 to 1.50) for 'leaving OR nursing'.

Similar results were observed for the association between asthma history and job changes over the period 2001–2011 among nurses in OR, ER, or inpatient units in 1997. In addition, increased asthma severity levels were associated with transition to a job with lower exposure (*P* for trend 0.004). No difference was observed according to asthma subtypes based on allergy or latex allergy (table 3).

## DISCUSSION

Asthma history is associated with both baseline job type and subsequent job changes among US nurses. Women with a

history of asthma were less often employed in nursing jobs likely to involve high disinfectant exposure at baseline, and they were more likely to move to jobs involving a lower level of exposure during follow-up. This association was more pronounced in nurses with more severe, persistent asthma. These results may partly reflect avoidance of tasks involving disinfectant use, and may introduce bias in cross-sectional studies on disinfectant exposure and asthma in nurses.

This analysis, conducted in a large prospective study of nurses followed up over 22 years, provides an example of the presence of health-related job selection among nurses. Several studies have suggested an association between asthma and avoidance of occupational exposures at risk for respiratory health.<sup>26</sup> Both initial and continuing selection processes have been observed: individuals with asthma before entering the workforce are more likely to choose work environments without hazardous exposures ('healthy worker hire effect');<sup>31–33</sup> and after entry in the workforce, exposed workers experiencing new onset or

**Table 2** Association between asthma status at baseline and job type in 1989, Nurses' Health Study II

Job type in 1989, %	Asthma before 1989		Age adjusted		Multivariable*	
	No (n=92 737)	Yes (n=5311)	Odds ratio	95% CI	Odds ratio	95% CI
Non-nursing job	4.0	4.3	0.96	0.82 to 1.12	1.00	0.86 to 1.16
Education or administration	13.2	14.8	1	–	1	–
Outpatient, other nurses	34.1	36.4	0.97	0.89 to 1.06	0.99	0.91 to 1.08
ER or inpatient unit	43.2	40.3	<b>0.89</b>	<b>0.82 to 0.97</b>	<b>0.89</b>	<b>0.82 to 0.97</b>
Operating room	5.5	4.2	<b>0.72</b>	<b>0.62 to 0.83</b>	<b>0.73</b>	<b>0.63 to 0.86</b>

Results in bold are statistically significant.

\*Adjusted for age, smoking status, body mass index, race and ethnicity. ER, emergency room.

**Table 3** Job changes according to asthma and asthma characteristics, among women employed in OR, ER or inpatient unit, Nurses' Health Study II

			Age adjusted		Multivariable*	
	Person-years	n Event (move to jobs with lower disinfectant exposure)	HR	95% CI	HR	95% CI
Job changes over 1991–2011, among nurses in OR, ER or inpatient unit in 1989, n=45 537						
Asthma before 1989						
No	623 166	29 330	1	–	1	–
Yes	31 270	1632	1.13	1.07 to 1.19	1.13	1.07 to 1.18
Job changes over 2001–2011, among nurses in OR, ER or inpatient unit in 1997, n=20 047						
Asthma before 1997						
No	207 533	10 270	1	–	1	–
Yes	23 430	1255	1.10	1.04 to 1.17	1.10	1.04 to 1.17
Allergy						
Asthma without allergy	2247	117	1	–	1	–
Asthma with allergy	17 223	922	1.04	0.86 to 1.26	1.05	0.87 to 1.28
Latex allergy†						
Asthma without latex allergy	18 561	990	1	–	1	–
Asthma with latex allergy	1026	56	1.06	0.81 to 1.39	1.08	0.83 to 1.43
Asthma severity‡						
Intermittent	8329	411	1	–	1	–
Mild persistent	7096	375	1.13	0.95 to 1.33	1.13	0.96 to 1.34
Moderate persistent	4612	257	1.27	1.05 to 1.53	1.26	1.04 to 1.52
Severe persistent	737	50	1.50	1.04 to 2.17	1.50	1.03 to 2.17

Results in bold are statistically significant.

\*Adjusted for age, smoking status, body mass index, race and ethnicity.

†Evaluated in 2001.

‡Evaluated in 1998 and/or 2003.

ER, emergency room; OR, operating room.

exacerbation of a pre-existing asthma are more likely to move to a non-exposed job ('health worker survivor effect').<sup>26 27</sup> In the current analysis, women were aged 24–44 years at baseline, and were thus observed at different periods in their working life. Associations between asthma history and job type at baseline were observed among women with childhood-onset as well as adult-onset asthma, and were suggested in younger as well as older nurses. The results are thus likely to reflect both a healthy worker 'hire' and 'survivor' effect among nurses.

In the US National Health and Nutrition Examination Survey (NHANES), a retrospective analysis of the association between childhood-asthma history and longest-held occupation showed that participants with a childhood-asthma history were more likely to work in health-related occupations (including, for instance, physicians, registered nurses or nursing aides).<sup>34</sup> Although these results may appear discrepant with the present results, they are compatible with our finding that women with asthma history avoid the specific nursing jobs likely to be more hazardous for respiratory health. To the best of our knowledge, the only other study examining job transfer related to respiratory health in healthcare occupation was conducted in 769 Canadian apprentices exposed to high molecular weight agents, including 122 dental hygiene apprentices.<sup>35</sup> Among them (as well as in animal health technology apprentices), a history of hay fever and possibly asthma and respiratory symptoms were predictors of quitting apprenticeship.

Other large studies of the association between asthma and subsequent job types or job changes generally investigated a wide range of occupations<sup>32 34 36</sup> and were thus more subject to confounding by socioeconomic factors or education level.<sup>37</sup> In the US NHANES, participants with asthma history were

found to achieve a higher education level than participants without asthma.<sup>34</sup> A prospective analysis in the French Epidemiological study on the Genetics and Environment of Asthma suggested that education and socioeconomic conditions may modulate asthma-based job selection.<sup>31</sup> The current findings, observed within a population of registered nurses likely to have a more homogeneous education level and socioeconomic status, strengthen the hypothesis that the association between asthma and subsequent job choice reflects an actual avoidance of occupations that pose a higher risk for respiratory health.

The hypothesis of an asthma-related job selection is further supported by the fact that asthma was well characterised in this large population of nurses.<sup>28</sup> Although in most analyses asthma was defined by a simple question (ever doctor-diagnosed asthma), results were systematically confirmed when we used data collected in supplementary asthma questionnaires to refine asthma definition. Moreover, stronger associations were observed across increasing levels of asthma severity. Finally, results remained similar after adjusting for two important and common risk factors (BMI, smoking status) for both asthma and other potential comorbidities (such as diabetes or cardiovascular diseases), supporting the specific role of asthma, rather than a more general poor health condition, in job selection.

Women with asthma were found to be employed less often and to select out of nursing jobs likely to involve a high level of disinfectant exposures. As we expected, and consistent with previous reports,<sup>38</sup> the highest level of self-reported disinfectant use in 2009 was observed in OR nursing, and elevated levels were also observed in ER or other inpatient units. Although patterns of disinfectants use (frequency and type of products) may have varied within each job type over the study period (1989–



2011), it is likely that higher exposure levels were constantly experienced in the same job types (OR, ER, inpatient units). However, disinfectant use may not be the only reason why asthmatic adults would avoid jobs such as nursing in OR, ER or inpatient units,<sup>16</sup> and no information was available in the current study about the specific reason for job change. Latex exposure, also at high risk for asthma, is likely to correlate with disinfectant exposure in nursing jobs. However, in this study, latex allergy was not associated with job change among women with asthma. In addition, asthma history was associated with leaving nursing in the OR, ER or inpatient unit similarly over the whole study period (1989–2011) and over the period 2001–2011, while the use of powdered latex gloves has been largely reduced in healthcare settings after 2000.<sup>19</sup> This suggests that our observations are not driven by latex avoidance. Other potential exposures that may influence job choices or changes among nurses with asthma include shift work or work-related stress. However, in the current analyses, stronger associations were observed when considering OR nursing alone. Nurses in the OR are the ones who reported the highest level of disinfectant exposures, but most (91%) did not report working in night shifts. As for work-related stress, although no information was available in this study, the literature suggests that perception of the numerous workplace stressors varies considerably even between nurses working in the same practice area.<sup>39</sup> Individual work stress in nurses would thus be poorly predicted considering job type only. Overall, we believe these factors are likely to have a minor role in the current results in comparison to exposure to cleaning and disinfecting chemicals.

The absence of data on use of disinfectants by nurses for most of the follow-up period, preventing us from studying potential change in disinfectant use according to asthma, was a limitation in this study. However, in healthcare facilities, nurses experience chemical exposures related to not only their own use of disinfectants, but also to cleaning and disinfection tasks performed by other workers in the same unit. It is also unclear to what extent most nurses have control of the disinfection tasks they perform and products they use, which depends on the healthcare facilities policies. For these reasons, the nurses' overall exposure level—and by extension their exposure avoidance strategies—may be better represented by their job type than by their own self-reported use of disinfectants.

Regardless of the exact reason why women with asthma would avoid nursing in the OR, ER or inpatient unit, the observed tendency may bias<sup>26</sup> the results of epidemiological studies on asthma among healthcare workers, including studies trying to examine the effect of exposure to various disinfectants and cleaning products. The association observed between asthma history and job changes during follow-up was modest (HR 1.13), but nurses with asthma were already less often employed in jobs with high disinfectant exposure at baseline, suggesting that part of asthma-related selection had occurred before start of follow-up. Overall, this healthy worker effect could have a large impact<sup>27</sup> in cross-sectional studies on disinfectant exposure and asthma in nurses. To avoid underestimation of associations between occupational exposures and asthma outcomes, a longitudinal design is strongly preferred, with collection of data on complete occupational history and asthma outcomes over time. To study time-varying asthma characteristics (eg, asthma severity or control, asthma exacerbations), appropriate statistical methods to adjust for time-varying confounding should also be considered.<sup>27</sup>

Among workers affected by occupational asthma, complete and definitive removal from exposure to the causal agent is

associated with better clinical outcomes, and is generally recommended as the preferred management strategy.<sup>2</sup> However, if job transfer is needed to avoid the causal agent, adverse economic, personal and professional consequences are increased.<sup>40</sup> Our results suggest that beyond their impact on the disease itself, exposures associated with asthma in healthcare occupations, including disinfectant exposures, affect career choices and mobility patterns in individuals with asthma. Work trajectories may have an important impact on wage outcomes in nursing jobs,<sup>41</sup> and job transfer is thus likely to cause an additional socioeconomic burden in affected workers.

As recently underlined,<sup>18 25</sup> there is an urgent need for further research to better identify the specific chemicals at risk for asthma in healthcare settings, before developing more adequate prevention and management strategies. Our findings emphasise the importance of addressing healthy worker effect bias in future respiratory epidemiological studies among healthcare workers. The choice of a longitudinal study design and an appropriate analytic strategy will be critical to evaluate accurately the effect of hazardous cleaning and disinfecting products on asthma.

#### Author affiliations

<sup>1</sup>Channing Division of Network Medicine, Department of Medicine, Brigham & Women's Hospital and Harvard Medical School, Boston, Massachusetts, USA

<sup>2</sup>Department of Emergency Medicine, Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts, USA

<sup>3</sup>INSERM, VIMA: Aging and chronic diseases. Epidemiological and public health approaches, U1168, F-94807, Villejuif, France

<sup>4</sup>UVSQ, UMR-S 1168, Université Versailles St-Quentin-en-Yvelines, Saint-Quentin-en-Yvelines, France

<sup>5</sup>Netherlands Institute for Health Services Research (NIVEL), Utrecht, The Netherlands

<sup>6</sup>Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, Morgantown, USA

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## Asthma history, job type and job changes among US nurses

Orianne Dumas, Raphaëlle Varraso, Jan Paul Zock, Paul K Henneberger, Frank E Speizer, Aleta S Wiley, Nicole Le Moual and Carlos A Camargo, Jr

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