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## **Under-estimation of self-reported occupational exposure by questionnaire in hospital workers**

C Donnay<sup>1</sup>, M-A Denis<sup>2,3</sup>, R Magis<sup>4</sup>, J Fevotte<sup>3,5</sup>, N Massin<sup>6</sup>, O Dumas<sup>7,8</sup>, I Pin<sup>9</sup>, D Choudat<sup>1,4</sup>, F Kauffmann<sup>7,8</sup>, N Le Moual<sup>7,8</sup>

<sup>1</sup>Université Paris Descartes, AP-HP, Paris, France

<sup>2</sup>Hospices Civils de Lyon, Groupement Hospitalier Est, Médecine du Personnel, Bron, F-69677, France

<sup>3</sup>UMRESTTE UMR T9405 (INRETS; Université de Lyon; Université Lyon 1; Institut de Veille Sanitaire), Bron, F-69500, France

<sup>4</sup>Service central de médecine du travail, AP-HP, Paris, France

<sup>5</sup>Institut de veille sanitaire, Département santé travail (DST/InVS), Saint Maurice, F-94415, France

<sup>6</sup>Département Epidémiologie en Entreprise, INRS, Vandœuvre-lès-Nancy, France

<sup>7</sup>Inserm, CESP Centre for research in Epidemiology and Population Health, U1018, Respiratory and environmental epidemiology Team, F-94807, Villejuif, France

<sup>8</sup>Université Paris Sud 11, UMRS 1018, F-94807, Villejuif, France

<sup>9</sup>Inserm, U823, Centre de Recherche Albert Bonniot, La Tronche, France

### **Corresponding author:**

Nicole Le Moual

Inserm U 1018 / CESP  
Centre for Research in Epidemiology and Population Health  
Respiratory and Environmental Epidemiology  
16, avenue Paul Vaillant Couturier  
94807 Villejuif Cedex, France  
e-mail: [nicole.lemoual@inserm.fr](mailto:nicole.lemoual@inserm.fr)  
Tel: 33 1 45 59 50 70  
Fax: 33 1 45 59 51 69

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## **ABSTRACT**

**Objectives:** The aim of the study was to determine whether self-reported occupational exposure to cleaning/disinfecting agents in hospital workers is accurate, in comparison to expert assessment, taken to be the gold standard.

**Methods:** In the Epidemiological study on Genetic and Environment of Asthma (EGEA), participants were interviewed on occupation with a specific questionnaire for hospital workers regarding tasks and cleaning/disinfecting agents. Two estimates of exposure were available: (1) self-report, (2) expert assessment. The expert assessment involved a standardised procedure to estimate intensity, frequency and probability of exposure for each job. The present analysis focused on eight specific exposures: formaldehyde, glutaraldehyde, bleach/chlorine, alcohol, quaternary ammonium components, ammonia, sprays, latex gloves. Agreement and differences between self-reported and expert estimates were studied by Kappa and Phi coefficients and McNemar tests, respectively.

**Results:** In the survey of 1571 adults, 176 ever hospital workers with both self-reported exposure to cleaning/disinfecting products or tasks and expert exposure assessments were studied, totalling 327 occupations. An underestimation of self-reported exposure was observed especially for formaldehyde (26.5% vs 32.7%,  $p=0.01$ ), ammonia (7.4% vs 18.8%,  $p<0.0001$ ), alcohol (64.9% vs 93.0%,  $p<0.0001$ ), and quaternary ammonium components (16.6% vs 70.9%,  $p<0.0001$ ), compared to expert assessment. The associations were confirmed when the analyses were stratified on socioeconomic level, asthma status, level of exposure. Asthmatic had fewer missing reports than non asthmatic participants.

**Conclusion:** Occupational exposure to disinfecting or cleaning agents is very common and high in hospitals. A large underestimation of self-reported exposure, and a lack of knowledge of product components, was observed. Our results show the relevance of expert assessment in epidemiological studies to limit measurement bias. This work underlines the necessity for better training of healthcare workers to improve their knowledge about occupational exposures and to develop health education programmes regarding occupational risks induced by this kind of products.

## INTRODUCTION

There is growing evidence that healthcare workers are at increased risk of asthma.[1, 2] Various cleaning/disinfecting products for healthcare hygiene are used every day by healthcare workers (nurses, auxiliary nurses, physicians, cleaners, dental assistants ...). To protect patients from nosocomial infections, the frequency of disinfecting or cleaning tasks has increased, as well as the use of cleaning and disinfecting sprays.[3] New substances, potentially asthmogenic, have recently been introduced into hospitals to substitute for some suspected carcinogenic products (i.e. formaldehyde).[4]

Healthcare workers may be exposed to high levels of a number of pollutants (cleaning, sterilizing, aerosolized medications ...) and particularly to sensitizers (latex, surface disinfectants, biocides ...).[5] Disinfecting and cleaning products such as bleach/chlorine, ammonia are irritants for the skin, nose and lung or are sensitizers (low molecular weight agents), such as biocides.[5] The most common products used in hospitals are disinfectants (chlorhexidine, glutaraldehyde, quaternary ammonium components) to sterilise medical instruments and to clean floors and surfaces. Cleaning/disinfecting products are complex mixtures of many chemical components and it is difficult to identify which specific substances may impact on the respiratory health of healthcare workers and increase their risk of asthma.[3] The type of products, the intensity and the frequency of exposure vary according to the type of cleaning or disinfecting tasks (e.g., quaternary ammonium components to clean floors, glutaraldehyde to sterilize endoscopic material).

The assessment of exposure of healthcare workers to cleaning/disinfecting agents remains a challenge in occupational epidemiological studies.[6] Occupational exposures, based on precise description of working tasks and the cleaning/disinfecting products used, as documented in specific questionnaires, should be more precise than estimates based only on job titles. However, self-reported exposure may lead to some degree of recall and misclassification bias.[6, 7] Assessment of exposure to cleaning and disinfecting products by experts might be more reliable.

The aim of the present study was to estimate whether self-reported occupational exposure to cleaning and disinfecting agents in hospital workers is accurate, when compared to an expert assessment of exposure, that is taken as the gold standard.

## **METHODS**

### **Population**

The French Epidemiological study on Genetic and Environment of Asthma (EGEA) survey is a case control study with family members of the asthmatic cases. The first survey (EGEA1) was conducted between 1991 and 1995 with 2047 participants; the protocol and characteristics of the participants have been described previously.[8] Around twelve years later (2003 to 2007), in a second survey (EGEA2), 92.2% of the initial population who were still alive, completed a short self-questionnaire and 77.1% answered the main questionnaire.[9] Detailed information including a description of occupational history and specific questionnaires for hospital healthcare and cleaning workers was recorded for 1571 adults. Responses to specific occupational questionnaires on tasks and exposures for hospital and cleaning workers were available for 294 participants, with 468 jobs (Figure 1). An expert assessment (see detail below) of exposure to pollutants was made for 198 workers in health or biological activities and cleaners in hospitals who were potentially exposed according to their 430 job history descriptions.

The present analysis includes 176 adults and their 327 jobs, with available estimates of exposure to pollutants from (i) the specific questionnaires completed by interview with the workers and (ii) the expert assessment of exposure.

Written consent was obtained from all participants at both surveys. Ethical approval to carry out the study was obtained for both surveys from the relevant committees (Cochin Port-Royal Hospital, Paris, for the first survey (EGEA1); Necker Enfants-Malades Hospital, Paris, for the second survey (EGEA2)).

### **Asthma status**

In this analysis, a participant was classified as asthmatic if he was recruited as an asthmatic patient from a chest clinic, or if he/she answered positively to one of two standardized questions: (1) Have you ever had attacks of breathlessness at rest with wheezing? (2) Have you ever had asthma attacks?.

## Estimation of exposure

The EGEA2 survey included an occupational questionnaire, with a detailed description of the tasks for each job or apprentice period, and there were specific questionnaires for interviewing cleaners and hospital workers, adapted from those of the European Community Respiratory Health Survey (ECRHS), describing tasks as well as cleaning and disinfecting agents used. Feasibility and validity phases were conducted to obtain a final version of these questionnaires.[10] An individual who had jobs with similar tasks and exposures may respond to only one specific questionnaire and information about other similar jobs was documented (see online supplement). It was the participant who decided which jobs had similar tasks, and if he had worked as a cleaner and also as a healthcare worker he responded to both specific questionnaires. From the questionnaires, the potential exposure to cleaning/disinfecting products was evaluated. Each job in the study (n=3746, Figure 1), was classified, according to a description of tasks, by two experts (JF, NM) blinded to asthma status, as potentially exposed or non-exposed to cleaning or disinfecting tasks. Cleaners working outside hospitals have heterogeneous exposure according to their industry, and it was difficult to find experts with knowledge of these exposures. After discussion with experts, it was decided to conduct an expert assessment of exposure only for healthcare workers and hospital cleaners (198 out of 294 participants with specific questionnaires, Figure 1). The expert assessment, blinded to asthma status, used a standardized procedure described below, and the opinions of three experts (CD, RM, MAD; occupational hygienist and occupational physicians in the hospital) were recorded for these hospital workers. The three experts had worked in various hospital units, for more than 10 years, and had a good knowledge of current and previous occupational exposures. A structured assessment form was used to document three types of cleaning/disinfecting tasks (disinfecting, cleaning, and both tasks) and 21 specific cleaning/disinfecting agents or groupings of these agents. Disinfecting and cleaning agents were identified both by reported chemical agents or brand names, that allowed the experts to identify the chemical components. The standardized expertise procedure was performed by job. Decision rules were defined, according to the experts' knowledge and the data available regarding product components [11], to estimate the intensity (non-exposed, low, moderate, high, environmental), frequency (non-exposed, <1 day/month, <1 day/week, 1-3 days/week,  $\geq 4$  days/week) and probability (non-exposed, <50%,  $\geq 50\%$ , 100%) of exposure. A bibliographic research provided the experts with the dates of marketing and the components of each product reported by

participants, from a French list of cleaning/disinfecting products used in hospitals (using all updates from 2000 to 2007).[11] General decision rules for coding the level of exposures were written for all large job categories such as nurses, auxiliary nurses, cleaners and doctors, taking into account the calendar years and the hospital units (emergency, surgery, ...). Participants working in surgery, emergency, and paediatric units were considered to have a higher probability of exposure than workers from outpatient or inpatient units. The intensity of exposure to alcohol varied according to hospital units and was considered as 'high' for nurses working in an operating room or in an intensive care unit, 'moderate' for nurses working in an inpatient unit or doing blood tests and 'low' for nurses working outside the hospital. Cleaners were considered less exposed to patient-care disinfectants than nurses and more exposed to surface cleaning/disinfecting products. Exposures were estimated for each job, taking into account the description of tasks and self-reported exposures. The expertise was done for each job category (nurses, cleaners ...) to have a better reproducibility of the expert step, as underlined in previous papers.[12] Before each meeting, each expert evaluated, independently, exposure for a given list of jobs (that differed for each expert) from the same job category (for example, decisions regarding exposure for cleaners were made the same day). Each expert's assessment of exposure, for each of the 18 specific exposures and the three tasks (disinfection, cleaning, and combined cleaning/disinfecting), was discussed and a final decision was taken by consensus of the three experts. All expert assessments were reviewed at the end to check the standardization of the decisions taken.

Two estimates of exposure were available: (i) self-reported: a 'never' self-reported (see questionnaire, online supplement), is considered as 'non-exposed' and a self-reported ('4-7 days/week' or '1-3days/week' or '< 1day/week') as 'exposed'; (ii) expert assessment: only jobs classified by the experts with a high probability of exposure (probability  $\geq 50\%$ ) to a given product were considered as 'exposed' and in other cases (non-exposed or probability  $< 50\%$ ) as 'non exposed', as previously discussed. [13]

## **Statistical analyses**

Analyses are presented for the eight specific exposures (formaldehyde, glutaraldehyde, bleach/chlorine, alcohol, quaternary ammonium, sprays, ammonia, and latex gloves) for which at least 10 participants reported an exposure. The present analysis was performed at the job level. Self-reported exposures were

compared to expert assessments, that were taken as the gold standard, for the 327 jobs with both questionnaire and expert assessment available (Figure 1).

Specificity and sensitivity were computed by specific exposures, by asthma status and according to the level of exposure. Differences between self-reported and expert assessments have been tested by the McNemar test, [14] and agreement was studied by calculating both Cohen's Kappa ( $\kappa$ , chance-corrected) and Phi ( $\phi$ , chance-independent) agreement coefficient. According to a recent paper,[6] Kappa estimates, which are classically used to quantify agreement, tend to underestimate the level of agreement when there are marked differences in the prevalence of exposure in a given cell. Phi estimates seems more adapted in this case. The strength of agreement for both Kappa and Phi coefficients were interpreted, as recommended: poor:  $<0$ ; slight: 0 to 0.2; fair: 0.2 to 0.4; moderate: 0.4 to 0.6; substantial: 0.6 to 0.8; almost perfect: 0.8 to 1. [15]

Analyses were stratified according to three categories of occupation (nurses; auxiliary nurses and cleaners; physicians), socio-economic status ('low level' such as cleaners and auxiliary nurses, laboratory technicians ...; 'high level' such as nurses, physicians, researchers ...), level of exposure according to task, age, gender and asthma status. As job exposure estimates were not independent (on average each participant had two jobs), two further analyses were performed by taking into account only one job per participant, the last one or secondly, the first one. As participants could respond to only one specific questionnaire (as jobs with similar tasks could be grouped, after giving the list of their other jobs they considered as similar), to avoid bias, analyses were also performed after exclusion of jobs with similar tasks. Analyses were also performed for all jobs performed in the last five years, to limit the effect of memory bias.

## RESULTS

The studied population (healthcare workers and cleaners in hospitals,  $n=176$ ) did not differ significantly from the population with only specific questionnaire information ( $n=118$ ), nor from EGEA2 participants with a job history but no specific questionnaire (1112 out of 1406, Figure 1) for age, asthma status and smoking habits. Participants were 46 years on average, most were women (74%), 52% had never smoked and 39% were asthmatic (this high prevalence is explained by the EGEA protocol) (Table 1). In their last



occupation, 25% of the subjects were working as nurses, 21% as physicians, 11% as auxiliary nurses, 6% as cleaners.

Self-reported estimates and expert occupational exposure assessments were compared for all the 327 described jobs (Table 2). Few participants were exposed to glutaraldehyde according to either estimates (only nurses or auxiliary nurses specialised in cold sterilisation of medical material were exposed), and results regarding this exposure are not reported in our analyses.

The results show significant under-estimation of self-reported exposure compared to expert exposure assessment for all hazards except sprays and latex gloves. For latex gloves and spray exposures, an over-estimation of self-reported exposures was observed. High sensitivity was observed for bleach/chlorine, spray, latex gloves (respectively 87%, 95% and 99%) with substantial to high agreement coefficients ( $\phi$ : 0.72 to 0.84). Phi and Kappa values were very similar for all products except for alcohol, ammonia, and quaternary ammonium components where Phi values were slightly higher than Kappa values. Low to fair agreement in estimates were observed for alcohol and quaternary ammonium components ( $\phi$ : 0.15 and 0.32 respectively). For the self-reported data, high rates of missing values ('don't know') were observed for formaldehyde (8.0%), glutaraldehyde (9.5%), and quaternary ammonium components (7.3%).

Analyses were stratified according to three categories of occupation: auxiliary nurses and cleaners, n=55, nurses, n=89 and physicians, n=96. A lower rate of self-reported missing values was observed in physicians. For auxiliary nurses and cleaners, poor to fair Kappa and Phi coefficients were observed for quaternary ammonium components, alcohol and ammonia ( $\phi$ : -0.43, 0.27 and 0.38 respectively), for nurses poor to fair Kappa and Phi coefficients for quaternary ammonium components, alcohol and formaldehyde ( $\phi$ : 0.05, 0.25, 0.37 respectively), with underestimations of self-reports whereas for physicians, only alcohol exposure was under-estimated (results not shown). The underestimation of exposure to quaternary ammonium components was higher in cleaners/auxiliary nurses than in nurses. Auxiliary nurses and cleaners were more exposed to ammonia and bleach/chlorine than nurses (expert assessment: 65.4% and 83.3% vs 2.6% and 51.1% respectively).

Separate analyses in younger (< 45 years) and older participants ( $\geq$  45 years), are presented in Table E1. Younger participants were less often exposed to formaldehyde (14.9 vs 41.4%; expert assessment) and more often exposed to sprays (47.8 vs 29.4%) than older participants. A higher underestimation of exposure was

observed in the younger compared to the older participants for alcohol, quaternary ammonium components and ammonia, whereas the expert assessment of exposure prevalences were similar, whatever the age.

Separate analyses in men (n=96 jobs) and women (n=231 jobs), showed in most cases, higher agreement levels, lower prevalences of exposure (except for formaldehyde), and higher sensitivity in men than in women (results not shown). More than 50% of jobs described in men and fewer than 20% in women were physicians. Strong underestimations of self-reported exposures were observed in women for formaldehyde, quaternary ammonium components, ammonia and alcohol and in men for alcohol and quaternary ammonium components.

When the analyses were restricted to jobs without similar tasks, Phi and Kappa coefficients were higher (except for ammonia), compared to results from Table 2, and significant underestimations of self-reported exposure were observed for formaldehyde, alcohol, quaternary ammonium and ammonia (table E2, online supplement). Similar underestimations were also observed when analyses were restricted to the first job of each participant (n=176, data not shown). For two further analyses, when analyses were restricted to the last 176 jobs or the 136 jobs during the five last years, similar results were observed with significant strong underestimations of self-reported exposure to quaternary ammonium components, alcohol and ammonia whereas no difference between expert and self-reported assessments were observed for formaldehyde (data not shown).

Analyses performed, separately in asthmatic and non asthmatic participants, are described in Table 3. Missing data rates were higher among non-asthmatic than among asthmatic participants for the self-reported exposures, especially for formaldehyde (11.3% vs 4.0%). The level of agreement between the two exposures estimates was similar or slightly stronger in asthmatic than in non-asthmatic participants, except for quaternary ammonium components. Large underestimations of self-reported exposures were observed in both non-asthmatic and asthmatic participants for quaternary ammonium components, ammonia and alcohol.

For jobs with exposure to cleaning/disinfecting tasks, stratified analyses according to the level of exposure showed higher Phi and Kappa coefficients for low than for high exposure jobs (table E3, online supplement). There were more missing values for self-reported exposure in high exposure jobs compared to lower exposure jobs for exposure to formaldehyde (14.9% vs 5.9%) and quaternary ammonium components

(12.6% vs 5.9%). Large underestimations of self-reported exposures were observed, especially for formaldehyde, quaternary ammonium components, alcohol and ammonia.

Stratified analyses according to socio-economic status, showed lower Phi and Kappa coefficients and higher rates of missing values, in low *versus* high socioeconomic level. Larger underestimations of self-reported exposures were observed for quaternary ammonium, and ammonia in low *versus* high socioeconomic level (data not shown).

## **DISCUSSION**

Occupational exposure to disinfecting and cleaning agents is very common in hospital workers and their exposure is high. The present analysis, of several hundred jobs, demonstrates a significant underestimation of self-reported occupational exposure especially for formaldehyde, ammonia, alcohol, and quaternary ammonium components, compared to expert assessment. These findings were confirmed when the analyses were stratified on socioeconomic level, age, gender, asthma status, level of exposure or job category.

### ***Under-estimate of cleaning/disinfecting products exposure***

In the present study, healthcare workers had a high probability of being exposed to cleaning and disinfecting products in particular nurses, auxiliary nurses, and cleaners. The common use of such products has been previously reported.[3, 4] In our study, reported exposure was underestimated compared to the expert exposure assessment, especially for nurses, auxiliary nurses, and cleaners. This underestimation of exposure was large for formaldehyde, ammonia and alcohol; hospital workers had little knowledge of the components in cleaning/disinfecting products used, especially for quaternary ammonium.

We tested the hypothesis that declaration biases are greater for jobs with similar tasks, because the participants responded only once for two or more jobs with similar tasks. The underestimation could be attributed in part to jobs with similar tasks; however analyses performed after excluding jobs with similar tasks are consistent with an underestimation of exposure. Similar results were observed when analyses were performed for the first job only (one job per subject). Furthermore, analyses restricted to the last jobs and to jobs in the five last years, confirmed a high underestimation of self-reported exposure for ammonia, alcohol,

quaternary ammonium components. No difference between self-reported exposure and expert exposure assessment were observed for formaldehyde, probably explained by a decrease in formaldehyde used in recent years. The present analyses suggest that the underestimation of self-reported exposure is not explained by a declaration or a memory bias. However, the hypothesis that declaration bias might explain this underestimation cannot be totally excluded.

The underreporting is likely to be explained by a lack of knowledge of the components in cleaning/disinfecting products used by nurses, auxiliary nurses, cleaners. Agreement level seems to be affected by socio-demographic characteristics, as previously underlined in a study comparing self-report to job exposure matrix (JEM) exposure estimates. [16] We have observed differences in agreement level according to age, gender and socioeconomic status. The higher underestimation observed in younger subjects might be explained by a better knowledge of exposure in older workers or by a cohort-based difference in tasks or in the perception of exposures. The differences observed by gender may be explained by socioeconomic status (more men than women were physicians). Low socio-economic status might explain in part the underestimation of exposure. Nurses seem to have a better knowledge of exposure to quaternary ammonium components than cleaners or auxiliary nurses. Physicians seem to have a better knowledge of the components of products than other hospital workers. However they underestimate exposure to alcohol and quaternary ammonium components. In hospitals, physicians participate in the development of cleaning/disinfecting guidelines, which may in part explain their better knowledge of product components.

Strategies need to be developed, with workplace interventions, to protect workers from cleaning/disinfecting exposures and to improve health.[3, 4] It would be useful to limit the use of harmful or allergenic products and to provide safer disinfectants and cleaning products.[2-4] In addition, to improve the exposure knowledge of workers, more training of healthcare workers would be helpful.

### ***Asthmatic and non-asthmatic participants***

Our results are consistent with previously reported differential misclassification bias in self-reported exposure in work-related asthma or rhinitis studies.[6, 7, 17] We observed an underestimation of self-reported exposure whatever the asthma status, that was slightly lower in asthmatics. No differential

misclassification related to asthma was reported for other environmental exposures, such as environmental tobacco smoke or exposure to pets, which may modify clinical characteristics of asthmatics.[18,19]

Asthmatic participants seem to have a better knowledge of their occupational exposure or to pay more attention to products used than non-asthmatic participants. Missing values rates were lower in asthmatic than in non-asthmatic participants and higher in the more exposed groups. Our results are consistent with previous reports[6, 7] which suggest higher sensitivity and lower specificity in self-reported exposure (compared to JEM estimates) by asthmatic compared to non asthmatic participants.

For exposure to bleach/chlorine, a described risk factor for asthma,[20, 21] no significant difference in exposure estimates were observed in asthmatic which was not the case in non asthmatic participants. In hospitals, bleach is often used undiluted (strong odor) which is not the case for other products. Odors are recognized triggers in asthma[6] which may partly explain the greater perception of exposure to bleach/chlorine in asthmatic than in non asthmatic participants.

### ***Exposure assessment***

Occupational exposures change with time and are different now to twenty years ago. The tasks of healthcare workers vary according to the evolution of medical techniques, substitution of products, and to new guidelines for healthcare hygiene. To study associations between exposures and respiratory health, exposure in most cases is estimated by self-reported and more recently by JEMs.[13, 22, 23] To date, two JEMs have been developed in healthcare workers,[24, 25] to estimate exposures to large groups of pollutants and tasks. In these JEMs, no specific information regarding the components of disinfecting/cleaning agents, or the probability and frequency of exposure were available. One of the strengths of our study is that self-reported exposures were compared to expert assessments, rather than to JEM assessments. Case by case expert assessment is often considered to be the most accurate method for retrospective exposure assessment.[26] Expert assessment might reduce misclassification bias and is considered to be more effective than JEM estimates, as it takes into account all individual occupational information. Some authors underline the limitations of JEM estimates, such as the lack of variability in exposure within jobs, even if in theory differential misclassification is less likely to be present.[6, 27] The expert method is long and expensive, especially the search for the chemical components in the products, which limits use of this method. It also

depends on the competency of the experts who need to have a good knowledge of workplace exposure, for all time-periods under study. Some authors have underlined limits in expert assessment, and indicated that there are not necessary reliable for all hazards.[26] For eight groups of experts, Mannetje et al showed high agreement for exposure when there was detailed information in the questionnaire and low agreement for specific exposures that were difficult to directly estimate from tasks (eg, chromium dusts). In our study, available information was detailed, including job, activity, precise description of tasks, start and end years of each job, and products used, which should increase the reliability of our expert assessments. This allowed, for example, to classify a nurse working in a medical outpatient clinic in dermatology as less exposed to disinfectant than a nurse working in endoscopy, limiting the measurement bias. Standardization of the expert assessment is also an important issue.[26] Our expert assessment was blinded to health status and by job category (nurses, cleaners ...) to provide a better reproducibility, with standardized decision rules as suggested previously.[12]

The low agreement observed between self-reported and expert estimates suggests that it is necessary to ask all the questions from the two specific questionnaires regarding tasks, products and exposures for each job with a positive response to targeted questions from the main questionnaires (similar to questions 18 and 15 from the specific questionnaires, online supplement). Although the tasks may be similar, exposures may change according to cleaning/disinfecting guidelines. For example, formaldehyde (a risk factor for diseases other than asthma) has been replaced by quaternary ammonium components to clean surfaces. The experts have taken into account the period of the job, to estimate exposure. We observed for most specific exposures, a high specificity and a more variable sensitivity according to hazards, these results being consistent with previous studies.[26] As recommended, we used both Kappa and Phi to assess concordance and we observed, as expected, higher Phi than Kappa values when the McNemar test was significant, consistent with the fact that Cohen's Kappa agreement underestimates the level of agreement when there are marked differences in exposure prevalence.[6] However whatever the agreement coefficients used, the conclusions were the same.

### ***Specific exposures***

As previously underlined, the reliability of exposure estimates depends on the products.[26] For exposures to formaldehyde, alcohol and quaternary ammonium components, we observed similar agreement to Delclos et al.[6] Joffe et al [28] underlined that lower sensitivities were observed for exposures described in chemically specific terms, which is consistent with our observation for ammonia, quaternary ammonium components and glutaraldehyde.

Self-reported exposure to quaternary ammonium components was always underestimated, in men and women, whatever the job category, age, socio-economic or asthma status. The lack of knowledge regarding the type of components, in daily use as cleaning products in hospitals, underlines the difficulties to obtain appropriate self-reported exposure estimates for this component. The open questions, to collect information on “brand name”, were useful in such instances (questionnaire, online supplement). Sometimes, the experts identified quaternary ammonium exposure only from the brand name, which may explain in part the underreporting of the hospital workers. Similarly, alcohol is a component in many hand-cleaning products. It is possible that participants had forgotten to report these, which may explain, in part, the underreporting.

An overestimate of exposure to latex gloves and sprays was observed. Our hypothesis was that this overestimate was explained by jobs with similar tasks at different periods. The expert group was able to correct the exposure estimates by taking into account the marketing date of each product. Analyses on jobs without similar tasks, show no overestimate for latex gloves or for sprays.

### ***Conclusion***

Occupational exposure to disinfecting or cleaning agents is very common in hospitals. Workers do not know or underestimate their exposure, when compared to an expert assessment. Our results underline the relevance of expert assessment in epidemiological studies to limit measurement bias. Occupational safety and health education programmes on occupational risks induced by disinfecting and cleaning products, need to be developed. Healthcare workers need training to improve their knowledge on the toxicological effects of cleaning and disinfecting products and to be instructed on how to handle these products, so that they are protected. The use of personal protective equipment (gloves, face mask, glasses) must be adapted to each specific task of healthcare workers.

**What this paper adds :**

- A large underestimation of self-reported exposure in comparison to expert assessment, probably explained by a lack of knowledge of cleaning/disinfecting product components in hospital workers, was observed in this study.
- This study underlines the relevance of expert exposure assessment in epidemiological studies, to limit measurement bias.
- Healthcare workers need better training to improve their occupational exposures knowledge to protect them from occupational risks, induced by disinfecting and cleaning products.



**Figure 1: Selection of the studied population**

**Table 1 : Description of the study population from the EGEA survey**

	All* n=176	Women n=131	Men n=45
<b>Age</b> , n [min-max]	46.1 [20-77]	45.3 [20-77]	48.4 [23-76]
<b>Asthma</b> , n (%)			
No	108 (61.4)	82 (62.6)	26 (57.8)
Yes	68 (38.6)	49 (37.4)	19 (42.2)
<b>Jobs with expert assessment</b> , n			
Total number, n[min-max]	327[1-12]	231[1-6]	96[1-12]
1 job	102	74	28
2 jobs	38	31	7
3 or more jobs	36	26	10
<b>Last job</b> , n			
Cleaner	10	10	0
Auxiliary nurse	21	19	2
Nurse	44	39	5
Physician	37	21	16
Other (physiotherapist, dentist, pharmacy, laboratory technician, ...)	64	42	22
<b>Smoking habits</b> , n (%)			
Non smokers	91 (51.7)	69 (52.7)	22 (48.9)
Former smokers	48 (27.3)	37(28.2)	11 (24.4)
Smokers	37 (21.0)	25 (19.1)	12 (26.7)

\* 327 jobs with both expert and self-reported exposure estimates available

**Table 2 : Comparison of self-reported to expert exposure assessments\* – all jobs (n=327)**

	n <sup>§</sup>	Self-reported exposure %	Expert exposure assessment %	Mc Nemar test p	Kappa	Phi	Sensitivity	Specificity
Formaldehyde #	287	26.5	31.2	0.009	0.60	0.61	64.9	92.2
Glutaraldehyde #	281	3.9	5.2	ns	0.52	0.52	46.7	98.5
Bleach, chlorine	323	45.2	48.6	0.02	0.82	0.82	86.8	95.1
Alcohol	313	64.9	92.4	<0.0001	0.21	0.32	69.1	90.9
Quaternary ammonium #	265	16.6	63.3	<0.0001	0.08	0.15	20.2	92.2
Ammonia	309	7.4	18.3	<0.0001	0.52	0.59	39.7	100.0
Sprays	322	39.3	35.2	0.01	0.84	0.84	94.8	91.3
Latex gloves <sup>§</sup>	300	80.7	71.3	<0.0001	0.69	0.72	98.6	63.9

\* Specific exposures listed: more than 10 participants exposed

§ Number of jobs without missing values for either of the two exposure estimates

# Job classified by experts as environmentally exposed (table E1, online supplement) to formaldehyde (n=13), glutaraldehyde (n=12), quaternary ammonium components (n=32) were excluded from the analyses of each concerned specific exposure

**Table 3 : Comparison of self-reported exposure to expert exposure assessments in non asthmatic and asthmatic participants**

	n <sup>§</sup>	Self-reported exposure %	Expert exposure assessment %	McNemar test p	Kappa	Phi	Sensitivity	Specificity
<b>Non-asthmatic participants (n=177 jobs)</b>								
Formaldehyde#	150	15.3	26.0	<0.001	0.60	0.63	53.9	98.2
Bleach, chlorine	175	39.4	48.6	<0.001	0.75	0.76	77.7	96.7
Alcohol	166	63.9	94.0	<0.0001	0.17	0.28	67.3	90.0
Quaternary ammonium#	148	14.2	69.6	<0.0001	0.13	0.27	20.4	100.0
Ammonia	164	6.7	17.1	<0.0001	0.52	0.59	39.3	100.0
Sprays	174	39.0	34.5	0.06	0.78	0.78	91.7	88.6
Latex gloves	162	75.9	64.2	<0.0001	0.72	0.75	100.0	67.2
<b>Asthmatic participants (n=150 jobs)</b>								
Formaldehyde#	137	38.7	40.1	ns	0.57	0.57	72.7	84.1
Bleach, chlorine	148	52.0	50.0	ns	0.91	0.91	97.3	93.2
Alcohol	147	66.0	91.8	<0.0001	0.26	0.36	71.1	91.7
Quaternary ammonium#	117	19.7	72.6	<0.0001	0.01	0.01	20.0	81.2
Ammonia	145	8.3	20.7	<0.0001	0.51	0.59	40.0	100.0
Sprays	148	39.9	37.2	ns	0.92	0.92	98.2	94.6
Latex gloves	138	86.2	79.7	0.02	0.62	0.64	97.3	57.1

<sup>§</sup> Number of jobs without missing values for either of the two exposure estimates

# Job classified by experts as environmentally exposed to formaldehyde (n=7 and n=6 for non asthmatic and asthmatic subject respectively)

and quaternary ammonium components (n=10 and n=22 for non asthmatic and asthmatic subject respectively) were excluded from the analyses of each concerned specific exposure

## **EGEA cooperative group:**

**Coordination:** F Kauffmann; F Demenais (genetics); I Pin (clinical aspects).

**Respiratory epidemiology:** Inserm U 700, Paris M Korobaeff (Egea1), F Neukirch (Egea1); Inserm 707, Paris : I Annesi-Maesano ; Inserm CESP/U 1018, Villejuif : F Kauffmann, N Le Moual, R Nadif, MP Oryszczyn ; Inserm U 823, Grenoble : V Siroux.

**Genetics:** Inserm U 393, Paris : J Feingold ; Inserm U 946, Paris : E Bouzigon , F Demenais, MH Dizier ; CNG, Evry : I Gut , M Lathrop.

**Clinical centers:** Grenoble : I Pin, C Pison; Lyon : D Ecochard (Egea1), F Gormand, Y Pacheco ; Marseille : D Charpin (Egea1), D Vervloet ; Montpellier : J Bousquet ; Paris Cochin : A Lockhart (Egea1), R Matran (now in Lille) ; Paris Necker : E Paty, P Scheinmann ; Paris-Trousseau : A Grimfeld, J Just.

**Data and quality management:** Inserm ex-U155 (Egea1) : J Hochez ; Inserm CESP/U 1018, Villejuif: N Le Moual, Inserm ex-U780 : C Ravault ; Inserm ex-U794 : N Chateigner ; Grenoble : J Ferran

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