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ORIGINAL ARTICLE

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Prevalence and risk factors for self-reported odour intolerance: the Skövde population-based study

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Abstract *Objectives*: The present study was performed to determine the prevalence of odour intolerance in adults with respect to both self-reported general intolerance and affective and behavioural consequences. Furthermore, we aimed to relate odour intolerance to explanatory variables and risk factors. *Method*: This is a cross-sectional, population-based epidemiological study. A random sample of 1900 inhabitants from the age of 20, stratified for age and gender, were recruited. Subjects were invited for clinical examinations that included questions about general odour intolerance, respiratory symptoms and smoking habits, as well as a smell identification test. The chemical sensitivity scale for sensory hyperreactivity (CSS-SHR) was used to quantify affective and behavioural consequences. *Results*: In total 1387 volunteers (73% of the sample) were investigated. The overall prevalence of self-reported general odour intolerance was 33% (95% confidence interval (CI): 30–36%), with problems mainly from the upper respiratory tract. The prevalence of affective and behavioural consequences of odour intolerance (CSS-SHR score ≥43) was 19% (95% CI: 15–22%). The risk for the latter condition was increased in women compared with men (odds ratio = 2.3: 95% CI: 1.5–3.6), but no increased risk was found related to current smoking or impaired sense of smell. *Conclusion*: This study demonstrates that intolerance to odours is a widespread problem in society, and that it is about twice as common in women than in men.

Keywords Chemical intolerance · Olfaction · Adults · Tobacco smoke · Epidemiology

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Introduction

Intolerance to odorous and pungent substances is a frequently reported problem in industrialised countries. In the medical literature it is most commonly called ''chemical sensitivity''; however, before 1995 no one had reported the prevalence of this problem in a general population (Kipen et al. 1995). In a subsequent telephone survey the prevalence of self-reported allergy and chemical sensitivity was obtained from 1000 households, and chemical sensitivity was reported by 33% of the individuals interviewed (Meggs et al. 1996). In a similar telephone survey, in which more than 4000 adults participated, 16% of respondents reported that they were ''allergic or unusually sensitive to everyday chemicals'' (Kreutzer et al. 1999). Although, during the last few decades growing attention has been focused on chemical sensitivity and intolerance to odours, it is not known if it is an increasing problem in society.

Odour intolerance is also frequently found among patients at allergy clinics (Johansson et al. 2002). Many patients with upper and lower airway complaints have pronounced intolerance to various odours such as perfumes, cleaning agents, flowers, car exhaust fumes and tobacco smoke. Patients often have difficulties describing odour intolerance symptoms, the most common being ''heavy breathing'', ''difficulty in getting air'', ''pressure across the chest'' and a ''blocked nose''. When lower airway symptoms predominate, the term ''asthma-like'' has been used, but a main feature among patients with these symptoms is the absence of bronchial

obstruction (Millqvist et al. 1998). The symptoms have been difficult to identify by physiological measurements and the effects of various medications are small or doubtful. People with chemical odour intolerance, a symptom of multiple chemical sensitivity, often report upper and lower respiratory symptoms, e.g. chest tightness (Baldwin et al. 1999). The suggested mechanism behind these symptoms is a sensory hyperreactivity (SHR) (Millqvist et al. 1998; Ternesten-Hasseus et al. 2002). Whether or not odour intolerance is an everyday problem for an individual largely depends on whether the odorous/pungent substances in the environment will cause affective reactions and behavioural disruptions in the individual's everyday life.

In order to quantify such self-reported reactions and disruptions we developed the chemical sensitivity scale (CSS) (Nordin et al. 2003, 2004). From 21 statements/questions in the CSS about common situations of exposure to odourants/sensory irritants we subsequently identified eleven statements that are particularly sensitive for discriminating SHR patients from controls (Table 1). The shortened scale that was consequently developed, called the ''CSS-SHR'', has favourable metric properties (Nordin et al. 2004).

The aim of the present study was to determine, in a general adult population, the prevalence of self-reported general odour intolerance (Part 1) and the prevalence of such sensitivity to odours that has affective and behavioural consequences for the individual (Part 2). Other aims were to determine the type and severity of symptoms induced by odorous/pungent substances, to relate odour intolerance to possible explanatory variables and to obtain normative data for the CSS-SHR.

Materials and methods

Part 1

The present investigation forms part of the Skövde population-based study, which is an all-embracing name for a cross-sectional investigation of an adult cohort being studied regarding rhinologic/respiratory disorders in Sweden (Johansson et al. 2003). The community of Skövde has about 49,000 inhabitants, 37,000 of whom are adults. Of these, 67% live in the city, 18% in villages and 14% in the countryside. A random sample of 1900 individuals aged 20 years or older was drawn from the government population roster, stratified for gender and divided into seven strata: 20–29, 30–39, 40–49, 50–59, 60–69, 70–79 and 80+ years. An invitation was sent by mail to present for a rhinologic examination and to complete a smell test and a questionnaire. The recipients were requested to telephone the clinic for a study appointment. Non-respondents received up to three reminders and, where possible, were also contacted by telephone. A signed informed consent form was obtained from each participant in the study. The study was carried out in accordance with the Declaration of Helsinki and was approved by the Ethics Committee at the University of Göteborg.

Six trained physicians gathered medical history and performed a rhinologic examination including nasal endoscopy, peak nasal inspiratory flow, and a structured interview, as presented previously (Johansson et al. 2002). Questions were designed to obtain relevant medical conditions, in accordance with a finnish questionnaire survey (Hedman et al. 1999). Nasal symptoms were identified by the following question: Are you bothered by—(a) nasal secretion, (b) nasal congestion, and (c) sneezing? Cough symptoms were assessed by the question: Do you have coughing problems? Asthma was identified by asking the questions: in the past 12 months, have you had symptoms of asthma or attacks of shortness of breath with wheezing? and Do you have problems inhaling cold air? Smoking habits were identified by means of validated questions with high specificity (Hedman et al. 1999), namely: Have you ever smoked regularly (i.e. almost every day for at least 1 year)?; For how many years have you smoked in total? (Exclude periods of not smoking, which lasted more than 6 months.); How much on average do you currently

Table 1 Items in the CSS-SHR

(A)	I would not mind living on a street with odorous/pungent car exhausts if the apartment I had was nice[a]
(B)	I am more aware of odorous/pungent substances than I used to be[a,b]
(C)	At movies, other people's perfume and aftershave affect/irritate me[a,b]
(D)	I am easily alerted by odorous/pungent substances[a,b]
(E)	I get used to most odorous/pungent substances without much difficulty[a]
(F)	How much would it matter to me if an apartment I was interested in renting was located close to a factory that emits odorous/pungent substances?[b,c]
(G)	In public places, I do not mind some smell of cigarette smoke[a]
(H)	Often I want a completely odour-free environment[a,b]
(I)	I find it hard to relax in a place that evokes odorous/pungent sensations[b,d]
(J)	I would not mind living in an apartment that has a weak smell[a]
(K)	I am sensitive to odorous/pungent substances[a,b]

[a] *Scale*: Agree strongly (0), agree (1), agree mildly (2), disagree mildly (3), disagree (4), disagree strongly (5). The numbers in *parenthesis* refer to the score given for that response

[b] Item scored in opposite direction before responses are summed

[c] *Scale*: It would completely deter me (0), or it would be very important (1), important (2), slightly important (3), or not important at all (4)

[d] *Scale*: Always (0), very often (1), often (2), occasionally (3), seldom (4), never (5)

smoke or did you smoke before you stopped (converted into cigarettes per day)?; and Do you currently smoke? Smoking was expressed in ''pack-years'', which was calculated by multiplying the number of packets of cigarettes smoked per day by the number of years of smoking. Individuals with odour intolerance were identified by the questions: Are you bothered by strong odours (e.g., perfume, cleaning agents or flower scents). If yes, state where you are bothered (i.e., have symptoms) and grade the strength of your symptoms. The alternatives were: 0 = no symptoms; 1 = minor symptoms; 2 = moderate symptoms; 3 = severe symptoms in each of these locations: nose; eyes; throat; lungs; and others (please define location).

Olfactory function was tested with the Scandinavian odour-identification test (SOIT), which consists of 16 odours, with four response alternatives for each of them (Nordin et al. 1998). The SOIT was developed for the Scandinavian population and has satisfactory test-retest reliability, split-half reliability and validity. As a test of identification, it tests olfactory functions that are important for human daily routines (detection sensitivity, quality discrimination and recognition) and therefore corresponds well with threshold tests (Nordin et al. 1998). Based on the results of the SOIT study (Nordin et al. 1998) we defined the cut-off score for hyposmia as ≤12 and for functional anosmia as ≤9, independently of age and gender. Furthermore, height and weight were measured and body mass index (BMI) was calculated.

Part 2

Self-reported odour intolerance with respect to affective and behavioural consequences was quantified by means of the CSS-SHR in half of the respondents who participated in Part 1 of this study (Table 1) (Nordin et al. 2004). Thus, 693 individuals were randomly selected after stratification for age and gender, and mailed the CSS-SHR to respond to and return by mail. If no response was obtained within 3 weeks, a second questionnaire was mailed. The unweighted sum of all eleven items makes up the individual's total CSS-SHR score (ranging from 1 to 55, a high score indicating high sensitivity). The suggested criterion for the diagnosis of SHR is a CSS-SHR score of ≥43, which has yielded a sensitivity of 73% and a specificity of 97% (Nordin et al. 2004).

Statistical analysis

Chi-square test and *t*-test were used for comparing individuals with and without odour intolerance. Since multiple tests (≥10) were used *P*-values of < 0.005 were considered statistically significant (Campbell and Machin 2000). To identify factors of importance for self-reported odour intolerance, a multiple logistic regression was fitted to the data. The following explanatory variables were selected in the model: age; gender; impaired olfactory function; smoking (pack-years and current smoking). To keep this model as parsimonious and plausible as possible, stepwise (forward and backward) selection procedures were used. The significance level for entry and removal of a variable was set at 5%. Odds ratios (ORs) including 95% confidence intervals (CIs), according to Wald, are presented for the dichotomous explanatory variables.

Results

Part 1

Of the randomly selected 1900 individuals, 1387 (73%) participated in the clinical investigation (Fig. 1). Besides unwillingness to participate, reasons for non-participation of the study varied; in the youngest group non-participation was mainly due to relocation, and in the oldest, mainly due to incapacity or death (Table 2).

In total 454 (33% (95% CI: 30–36%)) individuals reported general odour intolerance and women were found to be over-represented in this group (Fig. 2). Respiratory symptoms and current smoking were more common among individuals with odour intolerance, but not total amount of smoking (pack-years) or BMI (Table 3). The risk for odour intolerance was increased in women compared with men, OR = 2.0 (95% CI: 1.6–2.5); however, no increased risk was found related to age, current smoking or impaired sense of smell (according to the SOIT).

Frequencies of the different types of symptoms described by the 454 individuals with odour intolerance are shown in Fig. 3. In total, 35% reported ''other symptoms'', which commonly included various symptoms, mostly headache (72%) and nausea (16%). Of 454 individuals with odour intolerance, 50% reported light symptoms, 38% reported moderate and 12% reported severe symptoms. There was no obvious difference

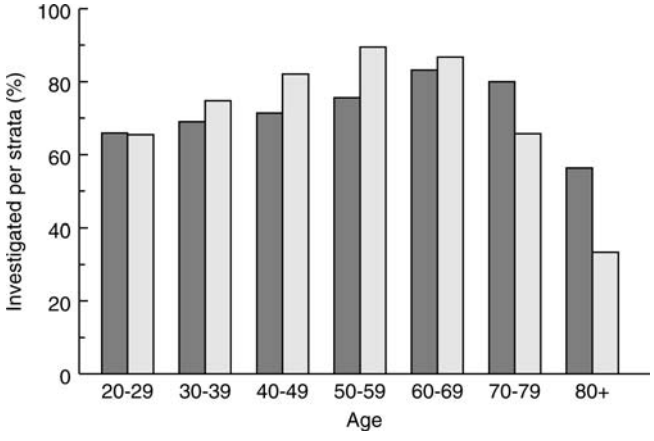

Fig. 1 Demographic details of the examined subset of the study population ($n = 1\ 387$). The bars represent the percentage of examined men (*dark*) and women (*light*) in each age strata

Table 2 Analysis of non-participation in the different age strata

Reason for non-participation	Total *n* (%)	Age strata (*n*)						
		20–29 years	30–39 years	40–49 years	50–59 years	60–69 years	70–79 years	80+ years
Unwillingness	204 (11%)	45	45	44	39	18	11	2
Relocation	47 (2%)	34	6	2	4	1	–	–
Incapacity	76 (4%)	–	2	2	2	6	25	39
Death	12 (1%)	–	–	1	–	1	5	5
No response/not reachable	174 (9%)	35	50	26	14	7	13	29
Total	513 (27%)	114	103	75	59	33	54	75

between men and women in the pattern of symptom severity.

Part 2

Of the randomly selected 693 individuals, 595 (86%) completed and returned the CSS-SHR. The 98 non-respondents were mostly young (< 40-year old) and elderly (> 80-year old) and in general were more often men than women.

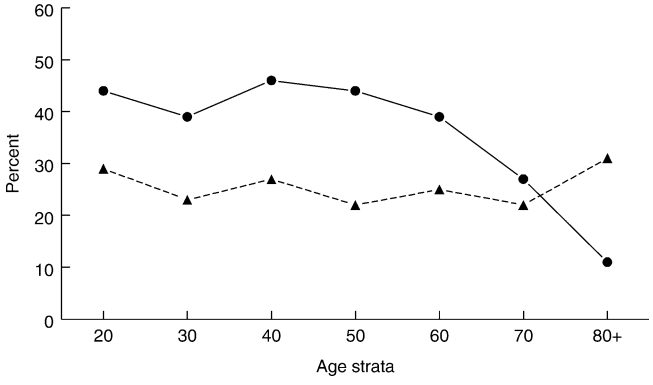

Fig. 2 Prevalence of odour intolerance among women (*circles*) and men (*pyramids*) in different age strata

Mean ± SD CSS-SHR score was 36.5 ± 8.3 (95% CI: 35.6–37.4) in women, 32.9 ± 8.0 (95% CI: 31.9–33.8) in men, 33.7 ± 8.0 (95% CI: 32.4–35.1) in young (20–34 years), 34.1 ± 8.2 (95% CI: 33.0–35.2) in middle aged (35–54 years), 36.2 ± 8.5 (95% CI: 35.1–37.3) in elderly (55 + years) adults, and 34.8 ± 8.3 (95% CI: 34.2–35.5) in the entire sample. Table 4 gives the distribution of CSS-SHR scores across the seven age strata. The measures of

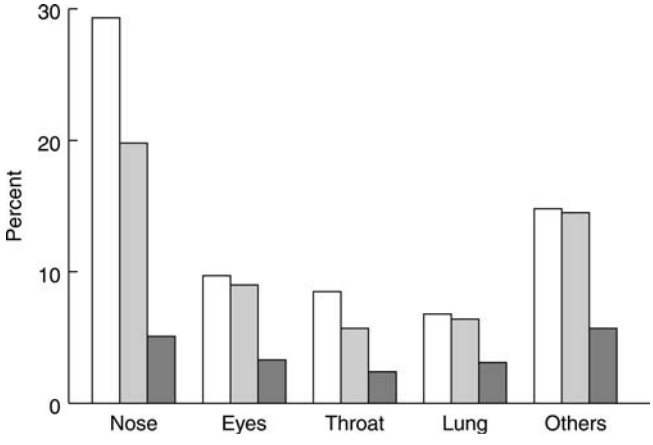

Fig. 3 Distribution of different types of symptoms among 454 individuals complaining of general odour intolerance. Of these 50% reported light symptoms (*white bars*), 38% moderate symptoms (*light grey bars*) and 12% severe symptoms (*dark bars*)

Table 3 Comparison of adult individuals with and without self-reported odour intolerance

Variables	Odour intolerant *n* = 454	Non-intolerant *n* = 933	*P*-values, statistical test
Women (%)	63.4	46.2	$P < 0.0001$, Chi-square test
Age (mean years)	47.7	49.8	Ns, *t*-test
BMI (W/L^2)	25.7	25.5	Ns, *t*-test
Nasal secretions (%)	35.5	21.7	$P < 0.0001$, Chi-square test
d Nasal congestion (%)	43.4	27.5	$P < 0.0001$, Chi-square test
Sneezing (%)	41.9	24.8	$P < 0.0001$, Chi-square test
Cough (%)	20.0	10.5	$P < 0.0001$, Chi-square test
Asthma (%)	16.7	6.0	$P < 0.0001$, Chi-square test
d Cold air problems (%)	23.6	10.2	$P < 0.0001$, Chi-square test
Current smoking (%)	21.6	14.6	$P < 0.005$, Chi-square test
Pack-years*	14.6	14.0	ns, *t*-test
SOIT (mean)	14.0	13.7	ns, *t*-test

* Pack-years were calculated by multiplying the number of packets of cigarettes smoked per day by the number of years of smoking
ns non-significant, *SOIT* Scandinavian Odor-identification test

Table 4 Evaluation, by a mailed questionnaire, of CSS-SHR scores in 595 respondents out of 693 individuals, divided into seven age strata: respondents, CSS-SHR score, and individuals with CSS-SHR ≥43

Strata	20–29 years	30–39 years	40–49 years	50–59 years	60–69 years	70–79 years	80+ years
Respondents (percent of the age group)	86 (79%)	108 (83%)	106 (85%)	125 (90%)	86 (91%)	63 (91%)	21 (78%)
CSS-SHR score	32.7	34.1	34.0	36.8	37.2	33.3	34.5
(mean ± SD)	±7.9	±7.9	±7.9	±8.8	±7.8	±8.9	±8.1
95% CI CSS-SHR	31.0–34.4	32.6–35.6	32.5–35.6	35.2–38.4	35.6–38.9	31.1–35.6	30.8–38.2
Skewness	−0.13	0.08	−0.28	−0.00	−0.29	0.20	0.24
Kurtosis	−0.31	0.02	−0.30	−0.71	0.09	−0.43	−0.66
CSS-SHR score ≥43	11 (13%)	16 (15%)	16 (15%)	38 (30%)	20 (23%)	10 (16%)	3 (14%)
95% CI CSS-SHR score ≥43	7–22%	10–23%	10–23%	23–39%	16–33%	9–27%	5–35%

CSS-SHR chemical sensitivity scale for sensory hyperreactivity, *CI* confidence interval, *SD* standard deviation

skewness and kurtosis were in general close to zero, suggesting approximately symmetrical and mesokurtic distributions for all strata (Table 4). Mean CSS-SHR scores were highest in the 50–59 and 60–69-year age groups. Mean CSS-SHR score was 38.4 in individuals with previously reported odour intolerance (Part 1) and 33.1 in the others. The difference was statistically significant ($P < 0.0001$).

Altogether 111 of the respondents met the CSS-SHR score criterion of ≥43. This gives a prevalence of 19% (95% CI: 15–22%) for odour intolerance with affective and behavioural consequences. Compared with those with a score <43, those with these consequences did not differ with regard to age, but women were over-represented, with 70% of women compared with 51% of men falling into this risk category ($P < 0.001$). The risk for a high CSS-SHR score was increased in women (OR = 2.3 (95% CI: 1.5–3.6)), but no increased risk related to age, current smoking (OR = 0.5 (95% CI: 0.3–1.1)), pack-year) or impaired sense of smell (OR = 0.8 (95% CI: 0.4–1.3)) was found.

Discussion

Non-participation to some extent is expected in any population-based study, and in the first part of this study the non-participation rate was 27%. An important question to ask in this regard is whether the sample can be considered as random or whether non-participation influenced the external validity of the study. The non-participants constituted a mixed group, about half of whom were unwilling to participate. However, odour intolerance is mostly of relatively low severity or morbidity, and there is therefore no reason to believe that the symptoms per se were a major reason for subjects electing not to participate in the study. Furthermore, in the invitation to the study no emphasis was placed on "odour intolerance" as a symptom. Rather, "olfactory ability" was presented to the subjects as the focus of the study. In some cases subjects were unreachable, although the random sample was drawn as late as one month before the study began. The non-participants were mostly among the youngest (34% of those aged 20–29 years) and oldest (58% of those aged 80+ years) age groups, while only 23% of those aged 30–79 years did not participate. In the second part of the study there were 14% non-respondents, with a similar age and gender distribution as in Part 1. This is of importance as high CSS-SHR scores were seen particularly between 50 and 69 years (Table 4). Consequently, the randomly selected individuals aged between 30 and 79 years can be considered as a fairly random sample and the influence on the prevalence of odour intolerance should not be overestimated. The demographic profile of Skövde compares well with that of Sweden in general, so that this population-based study can be considered representative of the Swedish population, and the estimated prevalence can be generalised (Johansson et al. 2003).

As many as one-third of the population reported some degree of odour intolerance, and half of them had moderate or severe symptoms from strong odours. High prevalence of odour intolerance has been reported in various populations, also with female predominance (Bell et al. 1993; Kipen et al. 1995; Kreutzer et al. 1999; Meggs et al. 1996). There is no obvious explanation for this, but in the present study the female preponderance was not due to distorted gender distribution in the recruited study population. Compared with subjects without odour intolerance, those with intolerance in this study more commonly reported respiratory symptoms (dominated from the upper airways), confirming previous findings of airway symptoms being common in this type of intolerance (Kipen et al. 1995; Kreutzer et al. 1999; Meggs et al. 1996). Apart from respiratory symptoms, many complained of headache from strong odours. The fact that the participants were given up to four invitations could have lead to an overestimation of the prevalence. However, when we compared the results from a group who responded after the fourth invitation with results from those who responded after the first, we found a slight, but non-significant, tendency towards higher prevalence in the former group.

The present results further suggest that odour intolerance affects daily life in 19% of the general adult population to such an extent that is has affective and behavioural consequences for the individual. In the future a population study of odour intolerance among children and teenagers would be of interest for evaluating both the onset of these problems and prevalence at

a younger age. Also of interest would be to record airway sensory reactivity with an objective method such as a capsaicin inhalation provocation in subjects randomised from a group of individuals with self-reported odour intolerance.

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