



International prevalence of fragrance sensitivity

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Abstract

Emissions and exposures from fragranced consumer products, such as air fresheners and cleaning supplies, have been associated with health problems and societal impacts. This study investigates effects of fragranced consumer products on the general population in four countries: United States, Australia, United Kingdom, and Sweden. Nationally representative population surveys ($n = 1137; 1098; 1100; 1100$) found that, across the four countries, 32.2% of adults (34.7%, 33.0%, 27.8%, 33.1% respectively) report fragrance sensitivity; that is, adverse health effects from fragranced consumer products. For instance, 17.4% report health problems from air fresheners or deodorizers, and 15.7% from being in a room cleaned with scented products. Commonly reported health problems include respiratory difficulties (16.7%), mucosal symptoms (13.2%), migraine headaches (12.6%), skin rashes (9.1%), and asthma attacks (7.0%). For 9.5% of the population, the severity of health effects can be considered disabling. Further, 9.0% of the population have lost workdays or lost a job, in the past year, due to illness from fragranced product exposure in the workplace. Personal estimated costs due to these lost workdays and lost jobs, across the four countries in one year, exceed \$146 billion (USD). A majority of people across the countries would prefer that workplaces, health care facilities and professionals, hotels, and airplanes were fragrance-free rather than fragranced. The study highlights a concern for public health and societal well-being, as well as an approach to reduce risks and costs: reduce exposure to fragranced products.

Keywords Fragrance sensitivity · Fragranced consumer products · Indoor air quality · Fragrance · Health effects

Introduction

“Fragrance sensitivity” is a health condition characterized by adverse health effects from exposure to fragranced consumer products (Caress and Steinemann 2009). A “fragranced consumer product” (or “fragranced product”) is a product that contains an added fragrance or that is largely comprised of fragrance (Steinemann 2016). Fragranced products can include air fresheners, deodorizers, cleaning supplies, laundry detergents, fabric softeners, essential oils, scented candles, soaps, personal care

products, colognes, and hand sanitizers, to name a few out of numerous everyday items. A single “fragrance” in a product is typically a complex mixture of dozens of compounds, many derived from petrochemicals (Sell 2006), among nearly 4000 documented fragrance ingredients (IFRA 2016).

No law in any country requires full disclosure of all ingredients in a fragrance. Instead of listing specific ingredients, a product may list the general term “fragrance” (or another legally accepted term, such as “perfume”). Further, no law requires full disclosure of all ingredients in a consumer product (other than for foods, drugs, and cosmetics), not even the general term “fragrance.” Thus, consumers have limited information about individual fragrance ingredients in a product as well as whether a product even contains a fragrance (Lunny et al. 2017; Steinemann 2009).

Exposure to fragranced products has been associated with a range of adverse human health and societal effects among the general population, and especially among vulnerable sub-populations such as individuals with asthma (Weinberg et al. 2017; Steinemann 2018c; Steinemann et al. 2018), autism (Steinemann 2018d), and chemical sensitivity (Steinemann 2019). Fragrance sensitivity can also be considered a disabling health condition that is covered under disability legislation in

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certain countries. However, relatively little research has investigated the prevalence of fragrance sensitivity, and more specifically links between fragranced consumer products and adverse health and societal effects.

This study investigates the effects of exposure to fragranced products on adults in four countries: United States (US), Australia (AU), United Kingdom (UK), and Sweden (SE). It builds upon and extends the individual national studies in the US, AU, UK, and SE (Steinemann 2016, 2017a, 2018a, b), offering greater breadth and depth of analysis, including new data and results on specific fragranced product exposures associated with specific health effects, amounts and costs of lost workdays and lost jobs, and comparisons and summaries across countries.

Methods

This international study is based on four nationally representative cross-sectional surveys of adults ages 18–65 in the US, AU, UK, and SE. Sample populations ($n = 1137, 1098, 1100, 1100$, respectively) were representative of the general populations according to age, gender, and region (confidence limit = 95%, margin of error = 3% for all studies). Using randomized participant recruitment, the surveys drew upon large web-based panels (with over 5,000,000; 200,000; 900,000; 60,000 participants, respectively) held by Survey Sampling International. For the panels, SSI uses multi-source samples to develop a blend that reflects the heterogeneity of the study population. For the surveys, recruitment followed a three-step randomization process to identify potential participants (see Electronic Supplementary Materials (ESM-[Methods](#) and ESM-[SSI](#))). The survey instrument, the same questionnaire in each country's native language, was developed and tested over a two-year period before full implementation in June 2016 (US, AU, UK) and June 2017 (SE). The survey response rates were 94%, 93%, 97%, and 92% (respectively), and all responses were anonymous. Descriptive statistics and cross-tabulations determined percentages according to each response and sub-population; see Electronic Supplementary Material (ESM-[Data](#)). The research study received ethics approval from the University of Melbourne. Survey methods are detailed in the Electronic Supplementary Material (ESM-[Methods](#)).

To promote comparability, the survey replicated questions from previous studies of fragrance sensitivity (Steinemann 2016, 2017a, 2018a, b, c, d, 2019; Steinemann et al. 2018; Caress and Steinemann 2009), as follows.

For fragrance sensitivity, the survey asked, “Do you experience any health problems when exposed to (fragranced product)?” If the respondent answered yes, the survey then asked about which health problems they experienced. An individual was considered to characterize fragrance sensitivity if they

reported one or more types of health problems from exposure to one or more types of fragranced consumer products.

Fragranced products were categorized as follows: (a) air fresheners and deodorizers (e.g., sprays, solids, oils, disks); (b) personal care products (e.g., soaps, hand sanitizer, lotions, deodorant, sunscreen, shampoos); (c) cleaning supplies (e.g., all-purpose cleaners, disinfectants, dishwashing soap); (d) laundry products (e.g., detergents, fabric softeners, dryer sheets); (e) household products (e.g., scented candles, restroom paper, trash bags, baby products); (f) fragrance (e.g., perfume, cologne, after-shave, essential oils); and (g) other.

Exposure contexts included the following: air fresheners or deodorizers used within indoor environments; scented laundry products coming from a dryer vent; being in a room after it was cleaned with scented cleaning products; being near someone wearing a fragranced product; and exposure to other types of fragranced consumer products.

Health effects were categorized as follows: (a) migraine headaches; (b) asthma attacks; (c) neurological problems (e.g., dizziness, seizures, head pain, fainting, loss of coordination); (d) respiratory problems (e.g., difficulty breathing, coughing, shortness of breath); (e) skin problems (e.g., rashes, hives, red skin, tingling skin, dermatitis); (f) cognitive problems (e.g., difficulties thinking, concentrating, or remembering); (g) mucosal symptoms (e.g., watery or red eyes, nasal congestion, sneezing); (h) immune system problems (e.g., swollen lymph glands, fever, fatigue); (i) gastrointestinal problems (e.g., nausea, bloating, cramping, diarrhea); (j) cardiovascular problems (e.g., fast or irregular heartbeat, jitteriness, chest discomfort); (k) musculoskeletal problems (e.g., muscle or joint pain, cramps, weakness); and (l) other.

Societal effects included the following: ability to access restrooms, businesses, public places, and other locations that use air fresheners or fragranced products; disabling effects; lost workdays or lost jobs due to fragranced product exposure; associated economic costs; and preferences for fragrance-free environments.

Results

This section provides the main findings, with summaries in Tables 1, 2, 3, and 4. Complete data and statistical analyses for each country individually, and across the four countries, are provided as Electronic Supplementary Material (ESM-[Data](#)).

Fragrance sensitivity prevalence, fragranced product exposures, and health effects

Among the general population in four countries, 32.2% of adults (34.7%, 33.0%, 27.8%, and 33.1%, respectively) report health problems when exposed to fragranced consumer products.

Table 1 Adverse health effects associated with exposure to fragranced consumer products

	US	AU	UK	SE	Sum/ average (%)
General population (<i>n</i>)	1137	1098	1100	1100	4435
Adverse health effects from fragranced products (fragrance sensitive)	34.7%	33.0%	27.8%	33.1%	32.2%
Health problems from exposure to					
Air fresheners or deodorizers	20.4%	16.4%	15.5%	17.3%	17.4%
Fragranced laundry products from dryer vent	12.5%	6.1%	6.0%	5.6%	7.6%
Room cleaned with fragranced products	19.7%	15.3%	14.0%	13.8%	15.7%
Someone wearing a fragranced product	23.6%	19.4%	13.7%	23.5%	20.1%
Other type of fragranced product	22.3%	20.3%	13.9%	17.9%	18.6%
Type of health problem					
*Migraine headaches	15.7%	10.0%	8.4%	16.1%	12.6%
*Asthma attacks	8.0%	7.6%	6.8%	5.5%	7.0%
*Neurological problems (e.g., dizziness, seizures, head pain, fainting, loss of coordination)	7.2%	4.5%	3.7%	5.0%	5.1%
*Respiratory problems (e.g., difficulty breathing, coughing, shortness of breath)	18.6%	16.7%	11.6%	20.0%	16.7%
*Skin problems (e.g., rashes, hives, red skin, tingling skin, dermatitis)	10.6%	9.5%	9.8%	6.5%	9.1%
*Cognitive problems (e.g., difficulties thinking, concentrating, or remembering)	5.8%	4.1%	2.8%	4.5%	4.3%
*Mucosal symptoms (e.g., watery or red eyes, nasal congestion, sneezing)	16.2%	14.0%	9.2%	13.5%	13.2%
*Immune system problems (e.g., swollen lymph glands, fever, fatigue)	4.0%	3.3%	1.9%	1.5%	2.7%
*Gastrointestinal problems (e.g., nausea, bloating, cramping, diarrhea)	5.5%	3.3%	3.0%	3.5%	3.8%
*Cardiovascular problems (e.g., fast or irregular heartbeat, jitteriness, chest discomfort)	4.4%	3.0%	3.2%	2.1%	3.2%
*Musculoskeletal problems (e.g., muscle or joint pain, cramps, weakness)	3.8%	2.6%	2.0%	1.5%	2.5%
*Other	1.7%	1.9%	2.1%	2.2%	2.0%

Fragranced product exposures associated with health problems, among the general population, include air fresheners and deodorizers (17.4%), fragranced laundry products from a dryer vent (7.6%), being in a room recently cleaned with fragranced products (15.7%), being near someone wearing a fragranced product (20.1%), and other types of fragranced consumer products (18.6%) (see Table 1).

Most common types of adverse health effects associated with these fragranced product exposures, among the general population, include respiratory problems (16.7%), mucosal symptoms (13.2%), migraine headaches (12.6%), skin problems (9.1%), asthma attacks (7.0%), and neurological problems (5.1%) (Table 1). More specifically, examining links between specific exposures and health effects for each country (Table 2), the highest average percentage (50.6%) is for respiratory problems from exposure to air fresheners and deodorizers.

Health effects from exposure to fragranced products can be considered disabling, according to legislative criteria that define disability in each country (ADAAA 2008; DDA 1992; EA 2010; DA 2008). Across the four countries, 9.5% of the general population, representing 29.1% of fragrance sensitive individuals (49.5% US, 17.1% AU, 25.5% UK, 24.2% SE), report health effects that can be considered disabling (Table 3).

Fragranced product exposures are associated with loss of societal access. Among the general population, 13.3% are unable or

reluctant to use restrooms in a public place if it has an air freshener, deodorizer, or scented product; 10.4% are unable or reluctant to wash their hands with soap in a public place if the soap is fragranced; 17.0% enter a business and then want to leave as quickly as possible if they smell air fresheners or a fragranced product; and 22.7% have been prevented from going someplace because they would be exposed to a fragranced product that would make them sick (see Table 3).

Exposures are also associated with lost workdays and lost jobs. Among the general population, 9.0% have lost workdays or lost a job, representing 27.5% of fragrance sensitive individuals, in the past year, due to illness from fragranced product exposure in the workplace.

Personal costs due to these workplace exposures are estimated by individuals to be $\$8.60 \times 10^{10}$ — $\$2.06 \times 10^{11}$; midrange value of $\$1.46 \times 10^{11}$, or \$146 billion (in terms of 2016 US Dollars). Given the estimated population affected, over 33 million people (USCB 2016; ABS 2016; ONS 2016; SCB 2017), this represents an estimated average annual cost of \$4300 per person. In terms of eight-hour equivalent days, the estimated losses across the four countries are over 200 million worker days per year (see Table 3).

Fragrance-free environments receive a majority of support (see Table 4). Among the general population, 47.8% would support a fragrance-free policy in the workplace (compared to 20.4% that would not); 51.4% would prefer that health care

Table 2 Adverse health effects associated with four types of exposure to fragranced products: air fresheners or deodorizers; scented laundry products coming from a dryer vent; being in a room after it has been cleaned with scented products; being near someone wearing a fragranced product

	Air fresheners					Scented laundry products				
	US	AU	UK	SE	Ave %	US	AU	UK	SE	Ave %
General population (n)	1137	1098	1100	1100		1137	1098	1100	1100	
Total (%) affected	20.4%	16.4%	15.5%	17.3%	17.4%	12.5%	6.1%	6.0%	5.6%	7.6%
Total (n) affected	232	180	170	190		142	67	66	62	
Health Effects (% of column total)										
Migraines	35.3%	25.6%	23.5%	38.9%	30.8%	26.1%	20.9%	22.7%	29.0%	24.7%
Asthma attacks	22.8%	27.2%	25.9%	18.9%	23.7%	19.7%	22.4%	34.8%	19.4%	24.1%
Neurological	15.5%	13.3%	8.8%	16.8%	13.6%	16.9%	11.9%	12.1%	9.7%	12.7%
Respiratory	46.6%	55.6%	44.7%	55.3%	50.6%	32.4%	41.8%	31.8%	30.6%	34.2%
Skin	28.0%	29.4%	29.4%	17.9%	26.2%	28.9%	34.3%	25.8%	32.3%	30.3%
Cognitive	13.4%	11.7%	8.2%	11.1%	11.1%	10.6%	16.4%	16.7%	11.3%	13.8%
Mucosal	37.1%	37.8%	28.8%	39.5%	35.8%	33.8%	25.4%	18.2%	27.4%	26.2%
Immune system	9.1%	11.1%	5.9%	3.7%	7.5%	13.4%	29.9%	13.6%	6.5%	15.9%
Gastrointestinal	13.4%	8.9%	10.0%	7.4%	9.9%	20.4%	19.4%	10.6%	4.8%	13.8%
Cardiovascular	12.9%	11.7%	13.5%	5.3%	10.9%	10.6%	22.4%	9.1%	9.7%	13.0%
Musculoskeletal	11.6%	10.0%	6.5%	2.6%	7.7%	16.2%	14.9%	12.1%	8.1%	12.8%
Other	3.4%	3.3%	4.1%	5.8%	4.2%	2.8%	3.0%	1.5%	8.1%	3.9%
	Scented cleaning products					Fragranced person				
	US	AU	UK	SE	Ave %	US	AU	UK	SE	Ave %
General population (n)	1137	1098	1100	1100		1137	1098	1100	1100	
Total (%) affected	19.7%	15.3%	14.0%	13.8%	15.7%	23.6%	19.4%	13.7%	23.5%	20.1%
Total (n) affected	224	168	154	152		268	213	151	259	
Health Effects (% of column total)										
Migraines	33.5%	22.6%	26.6%	44.7%	31.9%	35.8%	25.4%	24.5%	49.0%	33.7%
Asthma attacks	20.5%	16.1%	21.4%	13.8%	18.0%	16.4%	17.4%	16.6%	13.9%	16.1%
Neurological	21.0%	10.1%	11.7%	11.2%	13.5%	15.3%	12.2%	8.6%	10.8%	11.7%
Respiratory	48.7%	48.8%	42.9%	53.3%	48.4%	44.0%	42.7%	30.5%	59.5%	44.2%
Skin	20.1%	18.5%	23.4%	9.9%	18.0%	14.6%	8.9%	17.2%	6.9%	11.9%
Cognitive	13.8%	11.9%	10.4%	11.8%	12.0%	11.2%	8.0%	7.9%	11.2%	9.6%
Mucosal	37.1%	39.3%	26.6%	42.8%	36.5%	36.6%	40.8%	33.8%	33.2%	36.1%
Immune system	10.3%	10.7%	5.8%	2.6%	7.4%	7.1%	6.6%	3.3%	1.9%	4.7%
Gastrointestinal	14.3%	9.5%	7.1%	7.2%	9.5%	11.6%	7.5%	7.9%	9.7%	9.2%
Cardiovascular	11.6%	8.3%	7.1%	3.3%	7.6%	7.5%	6.1%	8.6%	3.1%	6.3%
Musculoskeletal	10.3%	6.5%	4.5%	2.0%	5.8%	6.3%	6.1%	7.3%	2.3%	5.5%
Other	1.8%	4.2%	5.8%	2.6%	3.6%	2.6%	4.2%	4.0%	3.5%	3.6%

facilities and professionals were fragrance-free (compared to 22.1% that would not); 60.7% would choose a hotel without fragranced air (compared to 22.1% with fragranced air); and 64.8% would choose an airplane without fragranced air (compared to 16.1% with fragranced air). Thus, in all categories, more than twice as many people would prefer fragrance-free environments and policies as not.

Demographic proportions of fragrance sensitivity across the four countries are 41.5% male and 58.6% female, compared with the general population of 48.9% male and 51.1% female. Thus, fragrance sensitivity has a female bias (+ 7.5%). Relative to gender and age, the highest bias (percentage fragrance sensitivity greater than general population) is female 45–54 (+ 2.9%) (see ESM Data-Tables 20 and 21).

Table 3 Societal effects associated with exposure to fragranced consumer products

	US	AU	UK	SE	Sum/ average %
General population (<i>n</i>)	1137	1098	1100	1100	4435
Fragrance sensitive (<i>n</i>)	394	362	306	364	1426
Adverse health effects from exposure to fragranced products	34.7%	33.0%	27.8%	33.1%	32.2%
Disabling health effects from fragranced product exposure					
(For general population)	17.2%	5.6%	7.1%	8.0%	9.5%
(For fragrance sensitive)	49.5%	17.1%	25.5%	24.2%	29.1%
Unable to use restrooms in public place because of air freshener or scented product	17.5%	11.6%	12.1%	12.0%	13.3%
Unable to wash hands because of fragranced soap	14.1%	10.3%	10.3%	6.7%	10.4%
Leave a business quickly because of fragranced product	20.1%	16.7%	13.1%	18.1%	17.0%
Prevented from access to some place because of fragranced product	22.7%	15.0%	13.5%	12.6%	22.7%
Lost workdays or lost jobs in past year due to fragranced product exposure in workplace					
(For general population)	15.1%	7.7%	6.3%	6.7%	9.0%
(For fragrance sensitive)	43.7%	23.5%	22.5%	20.3%	27.5%
Population affected	3.02×10^7	1.12×10^6	2.23×10^6	4.01×10^5	3.39×10^7
Lost workdays (8-h equivalents) due to fragranced product exposure	1.87×10^8	6.42×10^7	1.14×10^7	1.79×10^6	2.07×10^8
Lost workdays per person	6.2	5.7	5.1	4.5	5.1 (ave)
Personal economic costs in past year due to fragranced product exposure in workplace (2016 USD equivalent)	$\$1.32 \times 10^{11}$	$\$2.66 \times 10^9$	$\$1.05 \times 10^{10}$	$\$9.00 \times 10^8$	$\$1.46 \times 10^{11}$

Study strengths include the following: (a) sample populations in each country were statistically representative of age, gender, and region; (b) respondents were randomly recruited from large web-based panels developed from multiple sources to reflect population characteristics; and (c) the survey employed questions from large national studies previously conducted and published to promote replicability and comparability.

Study limitations include the following: (a) only adults ages 18–65 were included in the survey, which excludes other age groups; (b) the survey relied on self-reported data; however, self-report is a widely accepted method for survey

research; (c) the cross-sectional design of the survey represents data from only one point in time; and (d) all possible fragranced products and health effects were not included, although the relatively low percentages for responses in the “other” categories indicate the survey captured the primary products and effects.

Conclusion

Is fragrance sensitivity an epidemic? Given that nearly one-third of the population across four countries reports adverse effects, and that associated health effects and societal costs can be serious, the answer appears to be yes. In addition, a majority of the population in each of these four countries would prefer fragrance-free to fragranced environments.

Toward this goal, a practical approach would be to use products without fragrance (such as fragrance-free products) or to obviate the use of fragranced products (such as air fresheners) (e.g., Steinemann 2017b). Another step would be the listing of “fragrance” on the label for all types of consumer products (not only for foods, drugs, and cosmetics) so that consumers know whether a product contains fragrance. A further step would be a more complete disclosure and understanding of the specific ingredients in a product’s “fragrance.”

As studies have shown, fragranced consumer products can be primary sources of human exposure to potentially hazardous compounds (Hoang et al. 2017; Gokhale et al. 2008;

Table 4 Preferences for fragrance-free environments

	US	AU	UK	SE	Ave %
Fragrance-free workplaces					
Yes	53.1%	42.8%	44.7%	50.7%	47.8%
No	19.7%	22.2%	23.3%	16.4%	20.4%
Fragrance-free health care facilities and health care professionals					
Yes	54.8%	43.2%	43.3%	64.1%	51.4%
No	22.4%	25.2%	26.7%	14.0%	22.1%
Hotel without fragranced air					
Yes	55.6%	55.6%	53.8%	77.7%	60.7%
No	27.8%	22.7%	28.1%	9.8%	22.1%
Airplane without fragranced air					
Yes	59.2%	57.7%	61.9%	80.2%	64.8%
No	23.6%	16.3%	18.4%	6.0%	16.1%

Nazaroff and Weschler 2004), indoor air pollutants (Geiss et al. 2011; Edwards et al. 2001), as well as outdoor air pollutants (McDonald et al. 2018). Thus, reducing exposure could potentially benefit not only individuals but also society and the broader environment.

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Compliance with ethical standards

The research study received ethics approval from the University of Melbourne.

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