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## **Fragranced Consumer Products:**

### **Sources of Emissions, Exposures, and Health Effects in the United Kingdom**

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# **Emissions from Fragranced Consumer Products:**

## **Sources of Emissions, Exposures, and Effects in the United Kingdom**

### **Abstract**

Common in society, fragranced consumer products such as cleaning supplies and air fresheners are a primary source of volatile emissions that contribute to pollutants indoors and to personal exposure. Further, fragranced products have been associated with adverse health effects. This study investigates the sources of emissions, human exposures, and health and societal impacts from fragranced consumer products in the United Kingdom (UK). It examines the prevalence and types of fragranced product use, associated health effects, exposure situations, awareness of product emissions, and preferences for fragrance-free policies and indoor environments. Using a nationally representative population sample (n=1,100), data were collected in June 2016 using an online survey of adults in the UK, comprising England, Wales, Northern Ireland, and Scotland. Across the UK population, 27.8% report health problems, such as migraine headaches (8.4%) and asthma attacks (6.8%), when exposed to fragranced products. Yet 99.3% of the population are exposed to fragranced products at least once a week. When given a choice, more people would prefer that workplaces, health care facilities and professionals, hotels, and airplanes were fragrance-free rather than fragranced. Although fragranced products, even ones called green and organic, can emit potentially hazardous yet undisclosed pollutants, 75.0% of the population were not aware of this, and more than half would stop using their product if they knew it emitted such pollutants. This study provides important evidence that the UK population is regularly exposed to fragranced products, that these exposures are associated with adverse and often serious health effects, and that the public is largely unaware of their potential exposures. While more research is needed, reducing exposure to fragranced products, such as through fragrance-free policies, can provide an immediate step to reduce health risks and improve air quality.

**Keywords:** fragranced consumer product, fragrance, fragrance-free policy, indoor air quality

## Introduction

"Fragranced consumer products" (or for brevity "fragranced products") are chemically formulated products with the addition of a fragrance or scent (Steinemann 2015), and include numerous everyday products such as air fresheners, cleaning supplies, soaps, lotions, hand sanitizers, laundry detergents, baby shampoo, household items, and cosmetics. Fragranced products are pervasive in society; used daily in homes, workplaces, schools, businesses, transportation, and other public and private buildings; and used by individuals, industries, and institutions (Steinemann 2009).

Fragranced consumer products emit a complex mixture of dozens of volatile organic compounds (VOCs), such as terpenes (e.g., limonene, alpha-pinene, beta-pinene), ethanol, acetone, and acetaldehyde (Steinemann 2015), which can dominate pollutants found indoors. A study of homes in the UK found "unexpectedly high" indoor concentrations of limonene and alpha-pinene (five-day average up to  $1,439 \mu\text{g m}^{-3}$  and  $229 \mu\text{g m}^{-3}$  respectively), which were also the most abundant compounds in 94% of the homes and related to fragranced product use (Wang et al. 2017). In addition, fragranced product emissions of terpenes can generate a range of secondary pollutants, which include acetaldehyde, formaldehyde, and secondary organic aerosols (e.g., Carslaw 2013; Nazaroff and Weschler 2004).

Fragranced products have been associated with adverse health effects including headaches and migraines (Steinemann 2016, 2017; Kelman 2004; Farrow et al. 2003), asthma and asthmatic reactions (Steinemann 2016, 2017; Weinberg et al. 2017), breathing difficulties (Caress and Steinemann 2009), mucosal symptoms (Elberling et al. 2005; Millqvist and Löwhagen, 1996), and contact dermatitis (Johansen 2003; Rastogi et al. 2007). In two other studies parallel to this one, nationally representative surveys in the USA (Steinemann 2016) and Australia (Steinemann 2017) found that 34.7% and 33.0% of the population

(respectively) reported one or more type of adverse health effects from exposure to fragranced products.

Emissions from fragranced consumer products are generally unknown and undisclosed to the public. Currently, no law in the UK, or in any other country, requires the disclosure of all ingredients in fragranced consumer products (Lunny et al. 2017). Protections on ingredient disclosure depend on the product. First, for cosmetics, the general term "fragrance" (or "parfum") can be listed on the label, rather than the specific and numerous ingredients in the added fragrance. Second, for other types of consumer products, such as air fresheners, laundry supplies, cleaning products, and household items, ingredients do not need to be fully listed on the product label, not even the general term "fragrance."

Emissions from fragranced products create risks for both voluntary exposure and involuntary exposure. In an analogy to secondhand smoke, "secondhand scents" (Steinemann 2016) refers to indirect exposure to others' use of fragranced products. As a response, fragrance-free policies (similar to smoke-free policies) have been implemented by businesses, agencies, and institutions in the UK and other countries (e.g., CDCP, 2009; CCOHS, 2015) to restrict the use of fragranced products within indoor environments such as workplaces, schools, hospitals, and public places.

This article reports results from a population-based study of the UK to investigate the sources of emissions, exposures, and effects from fragranced consumer products. New data on the extent of the problems point to opportunities to reduce the adverse effects by reducing exposure to these types of products.

## Methods

Using a national random sample representative of age, gender, and region (n=1,100; confidence limit=95%, confidence interval=3%), an on-line survey was conducted of the adult UK population. The survey instrument was developed and tested over a two-year period before full implementation in June 2016. The survey drew upon participants from a large web-based UK panel (approximately 950,000 people) held by Survey Sampling International. Participant recruitment followed a randomized process as detailed in SSI (2016). All responses were anonymous. The survey response rate was 97%. The research study received ethics approval from the University of Melbourne. Demographic information is provided in Table 1. Details on the survey methodology, including the checklist for reporting results of internet e-surveys (CHERRIES, Eysenbach 2004), are provided in the Supplementary Material.

Survey questions investigated the following: use and exposure to fragranced products, both from one's own use and from others' use; health effects related to exposures to fragranced consumer products; specific exposure situations; impacts of fragranced product exposure in the workplace and in society; awareness of fragranced product ingredients and labelling; preferences for fragrance-free environments and policies; and demographic information.

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, and dishwashing soap); (d) Laundry products (e.g., detergents, fabric softeners, dryer sheets); (e) Household products (e.g., scented candles, toilet paper, trash bags, baby products); (f) Fragrance (e.g., perfume, cologne, after-shave); and (g) Other.

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); (j) Other.

Specific exposure contexts were investigated: air fresheners or deodorizers used in public restrooms and other places, scented laundry products vented outdoors, being in a room after it was cleaned with scented cleaning products, being near someone wearing a fragranced product, entering a business with the scent of fragranced products, fragranced soap used in public restrooms, and ability to access environments that used fragranced products.

In addition, questions investigated awareness of fragranced product emissions and ingredient disclosure, preferences for fragrance-free environments (e.g., workplaces, health care facilities, airplanes, and hotels), and lost workdays due to fragranced product exposure. Demographic questions were asked regarding age, gender, household income, and region in the UK.

## **Results**

Main findings are summarized in this section, with complete data for responses to the survey questions provided in the Supplementary Material.

*Fragranced product use:*

Of the general population surveyed in the UK, 98.5% are exposed to fragranced products at least once a week, from their own use: 71.4% air fresheners and deodorizers; 91.3% personal care products; 80.7% cleaning supplies; 83.7% laundry products; 77.3% household products; 75.7% fragrance; 2.0% other.

Further, 89.0% are exposed to fragranced product at least once a week, from others' use: 53.3% air fresheners and deodorizers; 60.0% personal care products; 49.4% cleaning supplies; 42.7% laundry products; 46.9% household products; 65.9% fragrance; 1.9% other.

Collectively, 99.3% of the population are exposed to fragranced products at least once a week from their own use, others' use, or both.

*Health effects:*

Overall, 27.8% of the population reported one or more types of adverse health effects from exposure to one or more types of fragranced products. The most common types of adverse effects were as follows: 11.6% respiratory problems; 9.2% mucosal symptoms; 8.4% migraine headaches; 9.8% skin problems; 6.8% asthma attacks; 3.7% neurological problems; 2.8% cognitive problems; 3.0% gastrointestinal problems; 3.2% cardiovascular problems; 1.9% immune system problems; 2.0% musculoskeletal problems; and 2.1% other. (See Table 2.)

Of the 27.8% of the population reporting adverse health effects, 53.9% are female and 46.1% are male. Thus, proportionately more females report adverse effects than males, relative to the general population (female 50.0%, male 50.0%). Among all gender and age group classifications, proportionately more females aged 35-44 report adverse effects (14.1%) relative to the general population (12.3%). (See Table 1.)

Specific fragranced products and exposure situations that trigger adverse health effects include the following (see Table 3):

Air fresheners and deodorizers: 15.5% reported health problems when exposed to air fresheners or deodorizers. This compares to studies of the USA and Australia (Steinemann 2016, 2017) that found 20.4% and 16.4% (respectively) reported health problems when exposed to air fresheners or deodorizers.

Scented laundry products vented outdoors: 6.0% reported health problems from the scent of laundry products coming from a dryer vent. This compares to studies of the USA and Australia (Steinemann 2016, 2017) that found 12.5% and 6.1% (respectively) reported health problems from the scent of laundry products coming from a dryer vent.

Fragranced cleaning products: 14.0% reported health problems from being in a room after it has been cleaned with scented products. This compares to studies of the USA and Australia (Steinemann 2016, 2017) that found 19.7% and 15.3% (respectively) reported health problems from being in a room after it has been cleaned with scented products.

Proximity to fragranced person: 13.7% reported health problems from being near someone who is wearing a fragranced product. This compares to studies of the USA and Australia

(Steinemann 2016, 2017) that found 23.6% and 19.4% (respectively) reported health problems from being near someone who is wearing a fragranced product.

Severity of the health problems resulting from exposure to one or more types of fragranced products was investigated, using language from the Equality Act (EA 2010) to determine disability: "Do any of these health problems cause a substantial, likely to recur, and adverse effect on your ability to carry out normal day-to-day activities?" Of those adversely affected by fragranced products, 25.5% answered yes, indicating that the severity of effects from fragranced product exposure was potentially disabling.

#### *Ingredient disclosure and product claims:*

Fragranced products, even ones called green or organic, typically emit numerous volatile organic compounds, including hazardous air pollutants, but relatively few are disclosed to the public (Steinemann 2015).

Of the general population surveyed, 68.4% were not aware that fragrance chemicals do not need to be fully disclosed on the product label or material safety data sheet. Also, 70.7% were not aware that fragranced products typically emit hazardous air pollutants such as formaldehyde, and 75.0% were not aware that even so-called natural, green, and organic fragranced products typically emit hazardous air pollutants. Yet 53.5% would not still use a fragranced product if they knew it emitted hazardous air pollutants.

#### *Societal and workplace effects:*

The use of fragranced products creates a cascade of effects throughout society. Of the general population, 12.1% are unable or reluctant to use the restrooms in a public place, because of the

presence of an air freshener, deodorizer, or scented product. Also, 10.3% are unable or reluctant to wash their hands with soap in a public place, because they know or suspect that the soap is fragranced. Further, 13.1% of the population reported that if they enter a business, and smell air fresheners or some fragranced product, they want to leave as quickly as possible. And 13.5% have been prevented from going to some place because they would be exposed to a fragranced product that would make them sick. Notably, 6.3% of the UK population reported that exposure to fragranced products in their work environment has caused them to become sick, lose workdays, or lose a job.

Fragrance-free policies receive support from nearly half of those surveyed. Of the population surveyed, 44.7% would be supportive of a fragrance-free policy in the workplace (compared to 23.3% that would not). Also, 43.3% would prefer that health care facilities and health care professionals be fragrance-free (compared to 26.7% that would not).

If given a choice between flying on an airplane that pumped scented air throughout the passenger cabin, or did not pump scented air throughout the passenger cabin, 61.9% would choose an airplane without scented air (compared to 18.4% with scented air). Thus, over 3 times more passengers would prefer an airplane without scented air than with scented air. Similarly, if given a choice between staying in a hotel with fragranced air, or without fragranced air, 53.8% would choose a hotel without fragranced air (compared to 28.1% with fragranced air). Thus, nearly 2 times more hotel guests would choose a hotel without fragranced air than with fragranced air.

## **Discussion**

Emissions from fragranced consumer products can impair indoor air quality, as prior studies have shown. This study demonstrates they can also impair human health, workplace productivity, access in society, and quality of life. Over one-fourth of the population in the

UK suffer adverse health effects when exposed to fragranced products. In nearly one-fourth of those individuals, the effects can be potentially disabling.

Of particular concern are exposure situations, often involuntary, that impose health risks and restrict access in society: 12.1% of the population are unable to use restrooms in public places because of air fresheners or deodorizers, 10.3% unable to wash their hands with soap in public places because of fragranced soap, and 13.5% unable to go someplace because of the presence of a fragranced product.

In addition, 15.5% report health problems from air fresheners and deodorizers used in public restrooms and elsewhere, 6.0% from scented laundry products coming from a dryer vent, 14.0% from being in a room after it was cleaned with scented products, and 13.7% from being near someone wearing a fragranced product.

Nearly half of those surveyed would prefer fragrance-free environments than fragranced environments. And 13.1% would enter but then leave a business as quickly as possible if they smell fragranced products. Significantly, 6.3% have lost workdays or a job due to fragranced product exposures in the workplace. A sensible solution is to implement a fragrance-free policy for workplaces, health care facilities, and other indoor environments.

Limitations of the study include the following: (a) all possible products and health effects were not included, although the low percentages for responses in the "other" category indicates the survey captured the primary products and effects, (b) data were based on self-reports, although a standard method for survey research, it was not possible to measure emissions, exposures, and effects directly for each respondent, (c) the cross-sectional design of the study, which useful for determining prevalence, is limited in the ability to determine temporal relationships and trends.

Results of this study provide important evidence that common fragranced consumer products are associated with adverse effects on human health and society. Together with the results from the US (Steinemann 2016) and Australia (Steinemann 2017), indicating that 34.7% and 33.0% (respectively) report adverse health effects, exposure to common fragranced products can be considered a widespread public health problem. Significantly, further research is needed to understand the types of product ingredients, emissions, and concentrations that are associated with these health effects. However, in the meantime, a prudent and practical approach to reduce adverse effects would be to reduce exposure, both voluntary and involuntary, to fragranced consumer products.

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Table 1: Demographic information.

	<b>Health Problems Fragranced Products</b>		<b>General Population</b>
	N % of column total	N % of general population row	N % of column total
<b>Total</b>	306	306	1100
	100.0%	27.8%	100.0%
<b>Male/Female</b>			
All Males	141	141	550
	46.1%	25.6%	50.0%
All Females	165	165	550
	53.9%	30.0%	50.0%
<b>Gender-Age</b>			
Male 18-24	20	20	83

	6.5%	24.1%	7.5%
Male 25-34	39	39	102
	12.7%	38.2%	9.3%
Male 35-44	30	30	107
	9.8%	28.0%	9.7%
Male 45-54	27	27	135
	8.8%	20.0%	12.3%
Male 55-65	25	25	123
	8.2%	20.3%	11.2%
Female 18-24	22	22	81
	7.2%	27.2%	7.4%
Female 25-34	41	41	129
	13.4%	31.8%	11.7%
Female 35-44	43	43	135
	14.1%	31.9%	12.3%
Female 45-54	33	33	108
	10.8%	30.6%	9.8%
Female 55-65	26	26	97
	8.5%	26.8%	8.8%

Table 2: Frequency and types of adverse health effects reported from exposure to fragranced consumer products.

Health Problems	Frequency (n) (% of general population)
<b>Total</b>	306
	<b>27.8%</b>
<i>Type of Health Problem</i>	
<b>Migraine headaches</b>	92
	8.4%
<b>Asthma attacks</b>	75
	6.8%
<b>Neurological problems</b>	41
	3.7%
<b>Respiratory problems</b>	128
	11.6%
<b>Skin problems</b>	108
	9.8%
<b>Cognitive problems</b>	31
	2.8%
<b>Mucosal symptoms</b>	101
	9.2%
<b>Immune system problems</b>	21
	1.9%
<b>Gastrointestinal problems</b>	33
	3.0%
<b>Cardiovascular problems</b>	35
	3.2%
<b>Musculoskeletal problems</b>	22
	2.0%
<b>Other</b>	23
	2.1%

Table 3: Frequency and types of health problems from exposure to four types of fragranced consumer products. AF = air fresheners or deodorizers, LP = scent of laundry products coming from a dryer vent, CP = being in a room after it has been cleaned with scented products, FP = being near someone wearing a fragranced product. (% of general population)

	Air Fresheners (AF)	Laundry Products (LP)	Cleaning Products (CP)	Fragranced Person (FP)
<b>Health Problems</b>				
(n)	170	66	154	151

(% of general population)	15.5%	6.0%	14.0%	13.7%
<i>Type of Health Problem</i>				
<b>Migraines</b>	3.6%	1.4%	3.7%	3.4%
<b>Asthma attacks</b>	4.0%	2.1%	3.0%	2.3%
<b>Neurological</b>	1.4%	0.7%	1.6%	1.2%
<b>Respiratory</b>	6.9%	1.9%	6.0%	4.2%
<b>Cognitive</b>	1.3%	1.0%	1.5%	1.1%
<b>Mucosal</b>	4.5%	1.1%	3.7%	4.6%
<b>Immune system</b>	0.9%	0.8%	0.8%	0.5%
<b>Gastrointestinal</b>	1.5%	0.6%	1.0%	1.1%
<b>Cardiovascular</b>	2.1%	0.5%	1.0%	1.2%
<b>Musculoskeletal</b>	1.0%	0.7%	0.6%	1.0%
<b>Other</b>	0.6%	0.1%	0.8%	0.5%