





Article

Long-Term Exposure to Essential Oils and Cardiopulmonary Health from a Population-Based Study

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Abstract: It is still unknown whether long-term inhalation of indoor air pollutants from ambient essential oil is associated with increased cardiopulmonary events. We recruited 200 healthy homemakers to conduct a prospective observation study in Northern Taiwan. We measured heart rate (HR), systolic blood pressure (SBP), diastolic BP (DBP), peak expiratory flow rate (PEFR), and indoor air pollutants four times per year for each participant between 2008 and 2018. Moreover, a questionnaire related to essential oil usage, home characteristics, and health status was filled out with each participant. The association between essential oil usage and cardiopulmonary health was determined using mixed-effects models. The mixed-effects models showed a significant association between essential oil usage and adverse cardiopulmonary effects including increased HR and BP and decreased % predicted PEFR among participants with heavy use of essential oils. No significant association between essential oils usage and adverse cardiopulmonary effects was observed among participants without essential oils usage or participants with mild use of essential oils (less than one hour per day). We concluded that exposure to indoor air pollution related to essential oils was associated with adverse cardiopulmonary effects among participants with essential oil usage more than one hour per day.

Keywords: essential oils; air pollution; peak expiratory flow rate; blood pressure; heart rate

1. Introduction

The adverse effects of poor indoor air quality on respiratory and cardiovascular systems among human subjects have been well documented in previous studies [1,2]. People's exposure to indoor air in houses, workplaces, public buildings, or transportation exceeds 80% in developed countries [3]. Therefore, indoor air pollution control is an important public health issue around the world. However, indoor air pollution prevention is not always technically feasible. Although technology is advancing, no single physical–chemical technology is capable of controlling all indoor air pollutants in a cost-effective manner [4].

Ambient aroma is a possible strategy for indoor air quality improvement. It has been widely used to ease stress and to improve the perception of comfort in houses and public

buildings [5]. The effects of ambient essential oil on stress relief [6,7], malodor elimination [5,8], and heart rate (HR) and blood pressure (BP) reduction [9] have been reported in previous studies. However, essential oil is a kind of volatile organic compound (VOC) composed of hundreds of aromatic chemicals [10]. VOCs have been reported to be associated with asthma [11], chronic bronchitis [12], adverse reproductive effects [13], and adverse cardiovascular effects [14]. Moreover, exceeding the threshold of the therapeutic effect of essential oils could be the beginning of the period of the toxic effect [15].

To date no study or report has demonstrated whether long-term use of essential oil for years may improve cardiopulmonary health or increase the risk of cardiopulmonary events among human subjects. The relationship between prolonged use of essential oils over hours and cardiopulmonary health remains to be elucidated. Therefore, we designed this population-based study to investigate this scientific issue. The objective of the present study was to investigate the effects of long-term essential oil usage on cardiopulmonary health by observing the association between BP, HR, lung function, and air pollutants among healthy subjects with different usage times of essential oils for ten years.

2. Materials and Methods

2.1. Participants and Study Design

Two hundred healthy homemakers aged 29 to 57 years, living in the Taipei–Keelung metropolitan area, joined the present study. The selection criteria included participants not smoking, having no known cardiopulmonary diseases and/or history of cardiopulmonary diseases that affected BP, blood pressure, and lung function, such as asthma, arrhythmia, chronic obstructive pulmonary disease, lung cancer, etc. We recruited participants by convenience sampling. Five hundred and eighty-seven participants responded to our campus advertisement or oral invitation by the principal investigator between January 2008 and December 2010; 513 of them (87%) met the selection criteria, accepted our protocol, were willing to participate in this study, and fulfilled our group definition of essential oil usage. A participant who had never used essential oil (any known essential oil for ambient air) was defined as a participant without essential oil usage. Participants who used essential oils less than one hour per day, between one hour and four hours per day, or more than 4 h per day were defined as participants with mild, moderate, or heavy use of essential oils, respectively. We selected 200 participants out of 513 eligible participants and made four groups of 50 participants, each with 25 males and 25 females. The protocol required 4 home visits per year (1 visit per three months) between 1 January 2009 and 31 December 2018. The HR, systolic BP (SBP), diastolic BP (DBP), peak expiratory flow rate (PEFR) and indoor air pollution were measured for each participant during each home visit. Moreover, a questionnaire related to age, sex, body mass index (BMI, a measure of body fat based on height and weight that applies to adult men and women), essential oil usage, home characteristics, and health status was conducted for each participant. The protocol was approved by the institutional review board of St. Mary's Medicine Nursing and Management College and the institutional review board of Taipei Medical University. Each participant provided written informed consent before the protocol initiation.

2.2. BP and HR Monitoring and Recording

We measured each participant's HR, SBP, and DBP at 30-min intervals during each home visit from 0900 to 2100 (12 h) using a portable BP monitoring system (DynaPulse model 5000A, Pulse Metric, San Diego, CA, USA). The participant held the DynaPulse system to monitor their resting HR and BP for six hours. Each participant yielded approximately 104 successful HR and BP measurements over four visits (24 measurements per visit) per year.

2.3. Indoor Air Pollution, Temperature, and Humidity Monitoring and Recording

Indoor total VOCs (TVOCs) were measured using a total VOC monitor (ppbRAE Plus, model PGM-7240, RAE Systems, Inc., San Jose, CA, USA). The calibration gas used

was isobutylene. The indoor fine particles (airborne particles $\leq 2.5 \mu\text{m}$ in aerodynamic diameter, $\text{PM}_{2.5}$), temperature, and relative humidity were measured continuously using a portable monitor (DUSTcheck Portable Dust Monitor, model 1.108; temperature and humidity sensor, model 1.153FH; Grimm Labortechnik Ltd., Ainring, Germany). We used a Rupprecht and Patashnick 1400a tapered element oscillating microbalance sampler (Thermo Electron Corporation, East Greenbush, NY, USA) to calibrate the DUST-check monitor in the laboratory. The raw data for 1-min indoor air pollutants measurements were matched with the sampling time of HR and BP monitoring to compute 1-min (current, lag 0), 1-h (lag 1) and 2-h (lag 2) mean data, if 75% of the data were present.

2.4. Peak Expiratory Flow Rate Measurement

We measured each participant's peak expiratory flow rate (PEFR) after air pollution monitoring by a peak flow meter (DofinTM, GaleMed Corporation, Taipei, Taiwan). All participants were trained to take three consecutive PEFR readings in the standing position at each home visit. If the variation of three consecutive readings of PEFR was $< 10\%$, the PEFR measurement was considered valid. The best value of the three readings was selected for use in further analysis.

2.5. Statistical Analysis

We employed a one-way analysis of variance (ANOVA) with Scheffe's mean comparison test to compare health variables and indoor air quality among participants based on the participants' essential oils usage. The associations of indoor air pollutants ($\text{PM}_{2.5}$ and TVOCs) with BP, HR, and PEFR were examined by mixed-effects models using R Statistical Software, V.3.5.0 [16]. The outcome variables were SBP, DBP, HR, and PEFR, while the exposure variables were $\text{PM}_{2.5}$ and TVOCs levels at 1-min (lag 0), 1-h (lag 1), and 2-h (lag 2) mean. Each regression model included fixed effects for age, sex, body mass index, education, family income, air conditioning times per week, window opening times per week, cooking times per week, cleaner using times per week, year and visit order, and random effect for the participant's identification number. The effects of indoor air pollutants on SBP, DBP, HR and % predicted PEFR were expressed as percent changes multiplied by the interquartile range (IQR) changes.

3. Results and Discussion

3.1. Results

The average age of the 200 participants was 42.6 years old {standard deviation (SD) = 3.9}, the average BMI was 25.8 kg/m^2 (SD = 1.6), and the male/female ratio was 1:1. There was no significant difference in age and BMI between the four groups of participants (ANOVA, p -value > 0.05). Moreover, there were five participants with asthma, two participants with adenocarcinoma, and four participants with acute myocardial infarction in the participants who used essential oils for more than 4 h per day. No cardiopulmonary disease was detected in participants who used essential oils for less than one hour per day (Table 1).

Table 2 shows that the participants with heavy use of essential oils had relatively higher levels of TVOCs and $\text{PM}_{2.5}$ exposure than those with moderate, mild, or no use of essential oils (Scheffe's test, p -value < 0.01). In addition, the participants with heavy use of essential oils had relatively higher SBP, DBP, and HR but relatively lower % predicted PEFR compared with those with moderate, mild, or no use of essential oils (Scheffe's test, p -value < 0.01). No significant difference in temperature or relative humidity among the four groups was observed.

Table 1. Basic characteristics of the 200 participants grouped by essential oil usage.

	None N = 50	Mild N = 50	Moderate N = 50	Heavy N = 50
Sex, no (%)				
Male	25 (50)	25 (50)	25 (50)	25 (50)
Female	25 (50)	25 (50)	25 (50)	25 (50)
Age, years				
Mean	41.3 ± 4.5	42.5 ± 3.8	42.1 ± 4.3	48.2 ± 3.1
Range	29–57	30–54	29–56	43–57
Body mass index				
Mean	25.4 ± 1.8	25.6 ± 2.2	25.3 ± 1.9	27.3 ± 2.1
Range	21.5–30.2	20.4–29.8	21.2–30.5	24.5–30.3
Health status in 2018				
Asthma	1	0	3	5
Adenocarcinoma	0	0	0	2
Acute myocardial infarction	0	0	2	4

Table 2. The statistical summary for peak expiratory flow rate, blood pressure, and heart rate at 1-h mean and environmental measurements at 1-h mean among 200 participants from 2008 to 2018 * (mean ± standard deviation).

	None	Mild	Moderate	Heavy	ANOVA	
					p-Value	Scheffe’s Test
SBP, mmHg	119.7 ± 21.1	110.1 ± 20.4	123.2 ± 21.8	131.4 ± 22.1	<0.01	Heavy/None/Mild /Moderate
DBP, mmHg	76.1 ± 18.3	72.4 ± 19.7	82.7 ± 20.8	88.6 ± 22.5	<0.01	
HR, beats/min	74.5 ± 7.2	72.9 ± 6.8	79.7 ± 7.2	84.1 ± 7.8	<0.01	
% predicted PEFR	91.2 ± 5.9	91.8 ± 6.4	89.2 ± 6.1	80.2 ± 7.6	<0.01	Heavy/None; Mild; Moderate
PM _{2.5} , µg/m ³	9.3 ± 4.4	10.8 ± 5.1	11.4 ± 6.2	16.8 ± 9.3	<0.01	Heavy/None/Mild /Moderate
TVOCs, ppm	0.43 ± 0.18	0.55 ± 0.27	0.77 ± 0.41	2.48 ± 1.65	<0.01	
Temperature, °C	24.2 ± 1.3	24.7 ± 1.1	23.9 ± 1.2	24.1 ± 1.6	0.22	-
Relative humidity, %	73.2 ± 2.3	74.2 ± 2.4	74.5 ± 2.2	73.6 ± 2.1	0.29	-

The associations between TVOCs and health measurements explored by mixed-effects models are shown in Table 3. Increases in BP and HR and decreases in % predicted PEFR were significantly associated with increased TVOC exposure among all participants. The IQR increases in lag 1 TVOCs (0.79 ppm) accounted for a 4.21% increase in SBP but a 2.92% decrease in % predicted PEFR. Moreover, the IQR increases in lag 2 TVOCs (0.99 ppm) accounted for 7.89%, 3.58%, and 3.22% increases in SBP, DBP, and HR, respectively, as well as a 4.28% decrease in % predicted PEFR. Moreover, we found that lag 1 and lag 2 TVOCs were significantly associated with increased SBP (6.88–10.89%), DBP (3.41–6.54%), and HR (3.44–5.67%) and decreased % predicted PEFR (5.67–9.88%) in participants with heavy use of essential oils. Moreover, the association of TVOC exposure with decreased SBP or HR was observed in participants with mild use of essential oils. There was no significant association between TVOCs and any health measurement among participants with moderate or no use of essential oils.

Moreover, we investigated the association between PM_{2.5} and health measurements by mixed-effects models (Table 4). We first analyzed the association of PM_{2.5} at lag 0, 1 and 2 with health measurements among all participants. The results showed that PM_{2.5} at lag 1 was consistently and significantly associated with all health measurements. Then we explored the association between PM_{2.5} at lag 1 and all health measurements for four groups. We only observed effects of PM_{2.5} at lag 1 on all health measurements among participants with heavy use of essential oils.

Table 3. Changes in health measurements resulting from an interquartile range change in lag0 to lag2 of total volatile organic compound levels in mixed-effects models.

Group	Lag	SBP	DBP	HR	% Predicted PEFR
All	0	1.35	−0.21	−0.01	0.43
	1	4.21 *	0.34	1.32	−2.92 *
	2	7.89 *	3.58 *	3.22 *	−4.28 *
None	0	0.24	−0.34	1.02	0.23
	1	1.21	0.88	0.13	−0.01
	2	0.98	−1.67	−0.55	1.91
Mild	0	−2.81 *	−1.34	−1.98 *	0.23
	1	0.89	0.78	−0.87	0.99
	2	−0.65	1.04	0.43	−0.76
Moderate	0	−0.43	−0.51	−0.42	0.34
	1	0.99	0.02	−0.45	−0.10
	2	1.23	0.72	0.88	0.52
Heavy	0	2.13 *	0.99	0.45	−1.23
	1	6.88 *	3.41 *	3.44 *	−5.67 *
	2	10.89 *	6.54 *	5.67 *	−9.88 *

* *p*-value < 0.01.**Table 4.** Changes in health measurements resulting from an interquartile range change of fine particles levels in mixed-effects models.

Group	Lag	SBP	DBP	HR	% Predicted PEFR
All	0	0.1	−0.23	0.76	−0.06
	1	2.77 *	1.89 *	1.73 *	−1.98 *
	2	2.12 *	0.66	−0.99	1.11
None	1	0.97	−0.32	0.61	−0.98
Mild	1	0.28	−0.13	1.02	0.67
Moderate	1	1.86 *	1.04	0.96	−0.06
Heavy	1	3.45 *	2.13 *	2.99 *	4.67 *

* *p*-value < 0.01.

3.2. Discussion

The present study focused on the long-term effect of essential oil on cardiopulmonary effects among healthy non-smoking homemakers. Basically, the study results suggest that exposure to essential oils more than four hours per day for approximately ten years was associated with increased BP and HR and decreased % predicted PEFR. These associations were more significant and consistent for TVOCs than the associations for PM_{2.5}. Moreover, the study results showed relatively more participants with cardiopulmonary events (asthma, adenocarcinoma, and acute myocardial infarction) in participants with heavy use of essential oils than participants without essential oil usage. Such study results may imply that long-term indoor TVOCs exposure from essential oils was the main effect on the cardiopulmonary system in these homemakers.

A previous study characterized the profiles and concentrations of emitted VOCs when evaporating essential oils indoors in Taiwan homes. The results showed that high emissions of linalool, eucalyptol, D-limonene, etc., were observed after the evaporation began, as the highest levels of VOCs in these essential oils appeared to emit into the indoor air [17]. Theoretically, these substances showed anti-inflammatory and anticancer properties in laboratory studies [18–20]. However, commercially available essential oils often contain fragrance ingredients and other undescribed or unknown ingredients. Fragrance ingredients are typically a complex mixture of several dozen to several hundred chemicals [21], primarily synthetic compounds [22]. Moreover, fragrances have been recognized as triggers for asthma [22] and adverse health effects, including migraine headaches, asthma attacks, respiratory difficulties, chest discomfort, fast or irregular heartbeat, etc. [23–25].

Therefore, the increased risk of long-term exposure to essential oils on the health of the human cardiovascular system is still worthy of attention and caution.

As in our previous study findings [14], the present study once again found that light use (less than one hour per day) of essential oils may help to reduce BP and HR. The main difference between this study and our previous study was the study population. Our past study was aimed at occupational users of essential oils, but the present study was conducted among non-occupational homemakers. Both studies confirmed the effect of light use of essential oils on the cardiovascular system, reported in previous studies. Seo [26] reported an association between essential oil aroma inhalation and a lower BP and pulse rate in female high school students. Sebastian and Kear [27] conducted aromatherapy inhalation to participants before a cardiac rehabilitation session over 8 min using lavender essential oil. BP, radial pulse, and stress levels were measured among participants in aromatherapy and non-aromatherapy sessions. The results showed a reduction in BP following both aromatherapy and non-aromatherapy sessions with no statistical significance between sessions and concluded that aromatherapy may be a useful stress management tool for cardiac rehabilitation patients. Kim et al. [28] investigated VOCs in essential oils and the effects of the inhalation of the essential oils in 10 adult male and female subjects. They observed that the subjects' SBP and HR decreased after inhalation of the essential oils. Accordingly, short-term exposure to essential oils may help to reduce BP and HR for physical relaxation.

The scientific evidence regarding the biological mechanism linking inhalation of essential oils to cardiopulmonary effects remains limited. However, inhalation of VOCs from essential oils or VOCs-related ozone (O₃) can be a possible explanation. O₃ is a secondary air pollutant formed by the photochemical oxidation of VOCs derived from air fresheners, cosmetics and deodorants, cleaners and disinfectants, etc. [29]. Inhalation exposure to VOCs, O₃, PM_{2.5}, etc., can induce pulmonary oxidative stress, inflammation, and autonomic dysfunction in human subjects. Long-term exposure to these air pollutants and recurrent cardiopulmonary inflammation may result in lung function impairment, myocardial infarction, lung cancer, etc. [30]. Therefore, our study findings imply that aromatherapy inhalation should focus not only on the positive effects of essential oils on physical relaxation but also on negative effects of overexposure to essential oils to minimize cardiopulmonary health risk.

There are some limitations should be addressed in our study. First, the association of essential oils exposure with increased BP and HR and decreased % predicted PEFr could be confounded by other unmeasured outdoor and indoor air pollutants. Second, we could not completely rule out all confounders, such as genetic factor, emotional variation, culture difference, etc., even though we have adjusted for a set of individual-level confounders. Third, it is still unknown whether the fluctuations of BP, HR and % predicted PEFr are associated with observed or future cardiopulmonary events, even if these health measurements can serve as markers for increased risks of cardiopulmonary diseases. Fourth, we were unable to define concentrations of essential oils to cause adverse or beneficial effects due to lack of qualitative and quantitative analysis data for ambient essential oils. Finally, we did not measure essential oils in flavorings, food, candy, sanitizers, etc. Therefore, we might have overestimated the effects of ambient essential oils on cardiopulmonary systems.

4. Conclusions

We concluded that healthy homemakers with heavy use (more than four hours per day) of essential oils had significantly higher levels of TVOCs and PM_{2.5} exposure than those with mild (less than one hour per day) or no use of essential oils. Long-term usage of essential oils less than one hour per day over a decade was associated with decreased BP and HR. Moreover, prolonged exposure to essential oils for more than four hours per day over a decade was associated with increased BP and HR.

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References

- Alford, K.L.; Kumar, N. Pulmonary Health Effects of Indoor Volatile Organic Compounds—A Meta-Analysis. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1578. [[CrossRef](#)] [[PubMed](#)]
- Lee, K.K.; Bing, R.; Kiang, J.; Bashir, S.; Spath, N.; Stelzle, D.; Mortimer, K.; Bularga, A.; Doudesis, D.; Joshi, S.S.; et al. Adverse health effects associated with household air pollution: A systematic review, meta-analysis, and burden estimation study. *Lancet Glob. Health* **2020**, *8*, e1427–e1434. [[CrossRef](#)]
- European Commission. *Indoor Air Pollution: New EU Research Reveals Higher Risks than Previously Thought*; European Commission: Brussels, Belgium, 2003.
- González-Martín, J.; Kraakman, N.J.R.; Pérez, C.; Lebrero, R.; Muñoz, R. A state-of-the-art review on indoor air pollution and strategies for indoor air pollution control. *Chemosphere* **2021**, *262*, 128376. [[CrossRef](#)]
- Spence, C. Using Ambient Scent to Enhance Well-Being in the Multisensory Built Environment. *Front. Psychol.* **2020**, *11*, 598859. [[CrossRef](#)] [[PubMed](#)]
- McCaffrey, R.; Thomas, D.J.; Kinzelman, A.O. The effects of lavender and rosemary essential oils on test-taking anxiety among graduate nursing students. *Holist. Nurs. Pract.* **2009**, *23*, 88–93. [[CrossRef](#)]
- Hur, M.H.; Yang, Y.S.; Lee, M.S. Aromatherapy massage affects menopausal symptoms in Korean climacteric women: A pilot-controlled clinical trial. *Evid. Based Complementary Altern. Med.* **2008**, *5*, 325–328. [[CrossRef](#)]
- Schifferstein, H.N.; Talke, K.S.; Oudshoorn, D.J. Can Ambient Scent Enhance the Nightlife Experience? *Chemosens. Percept.* **2011**, *4*, 55–64. [[CrossRef](#)]
- Chuang, K.J.; Chen, H.W.; Liu, I.J.; Chuang, H.C.; Lin, L.Y. The effect of essential oil on heart rate and blood pressure among solus por aqua workers. *Eur. J. Prev. Cardiol.* **2014**, *21*, 823–828. [[CrossRef](#)]
- Holman, C. Sources of air pollution. In *Air Pollution and Health*; Holgate, S.T., Sammet, J.M., Koren, H.S., Maynard, R.L., Eds.; Academic Press: London, UK, 1999; pp. 115–148.
- Moscato, G.; Galdi, E. Asthma and hairdressers. *Curr. Opin. Allergy Clin. Immunol.* **2006**, *6*, 91–95. [[CrossRef](#)]
- Leino, T.; Tammilehto, L.; Luukkonen, R.; Nordman, H. Self reported respiratory symptoms and diseases among hairdressers. *Occup. Environ. Med.* **1997**, *54*, 452–455. [[CrossRef](#)]
- Staessen, J.A.; Nawrot, T.; Hond, E.D.; Thijs, L.; Fagard, R.; Hoppenbrouwers, K.; Koppen, G.; Nelen, V.; Schoeters, G.; Vanderschueren, D.; et al. Renal function, cytogenetic measurements, and sexual development in adolescents in relation to environmental pollutants: A feasibility study of biomarkers. *Lancet* **2001**, *357*, 1660–1669. [[CrossRef](#)]
- Ma, C.M.; Lin, L.Y.; Chen, H.W.; Huang, L.C.; Li, J.F.; Chuang, K.J. Volatile organic compounds exposure and cardiovascular effects in hair salons. *Occup. Med.* **2010**, *60*, 624–630. [[CrossRef](#)] [[PubMed](#)]
- Lizarraga-Valderrama, L.R. Effects of essential oils on central nervous system: Focus on mental health. *Phytother. Res.* **2021**, *35*, 657–679. [[CrossRef](#)] [[PubMed](#)]
- R Development Core Team. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2010; ISBN 3-900051-07-0.
- Su, H.J.; Chao, C.J.; Chang, H.Y.; Wu, P.C. The effects of evaporating essential oils on indoor air quality. *Atmos. Environ.* **2007**, *41*, 1230–1236. [[CrossRef](#)]
- Chang, M.Y.; Shieh, D.E.; Chen, C.C.; Yeh, C.S.; Dong, H.P. Linalool Induces Cell Cycle Arrest and Apoptosis in Leukemia Cells and Cervical Cancer Cells through CDKIs. *Int. J. Mol. Sci.* **2015**, *16*, 28169–28179. [[CrossRef](#)]
- Boukhatem, M.N.; Sudha, T.; Darwish, N.H.E.; Chader, H.; Belkadi, A.; Rajabi, M.; Houche, A.; Benkebailli, F.; Oudjida, F.; Mousa, S.A. A New Eucalyptol-Rich Lavender (*Lavandula stoechas* L.) Essential Oil: Emerging Potential for Therapy against Inflammation and Cancer. *Molecules* **2020**, *25*, 3671. [[CrossRef](#)]

20. Yu, X.; Lin, H.; Wang, Y.; Lv, W.; Zhang, S.; Qian, Y.; Deng, X.; Feng, N.; Yu, H.; Qian, B. d-limonene exhibits antitumor activity by inducing autophagy and apoptosis in lung cancer. *OncoTargets Ther.* **2018**, *11*, 1833–1847. [[CrossRef](#)]
21. Bickers, D.R.; Calow, P.; Greim, H.A.; Hanifin, J.M.; Rogers, A.E.; Saurat, J.H.; Glenn Sipes, I.; Smith, R.L.; Tagami, H. The safety assessment of fragrance materials. *Regul. Toxicol. Pharmacol.* **2003**, *37*, 218–273. [[CrossRef](#)]
22. Zock, J.P.; Plana, E.; Jarvis, D.; Antó, J.M.; Kromhout, H.; Kennedy, S.M.; Kunzli, N.; Villani, S.; Olivieri, M.; Torén, K.; et al. The use of household cleaning sprays and adult asthma: An international longitudinal study. *Am. J. Respir. Crit. Care Med.* **2007**, *176*, 735–741. [[CrossRef](#)]
23. Clausen, P.A.; Frederiksen, M.; Sejbæk, C.S.; Sørli, J.B.; Hougaard, K.S.; Frydendall, K.B.; Carøe, T.K.; Flachs, E.M.; Meyer, H.W.; Schlünssen, V.; et al. Chemicals inhaled from spray cleaning and disinfection products and their respiratory effects. A comprehensive review. *Int. J. Hyg. Environ. Health* **2020**, *229*, 113592. [[CrossRef](#)]
24. Wolkoff, P.; Nielsen, G.D. Effects by inhalation of abundant fragrances in indoor air—An overview. *Environ. Int.* **2017**, *101*, 96–107. [[CrossRef](#)] [[PubMed](#)]
25. Steinemann, A. Fragranced consumer products: Exposures and effects from emissions. *Air Qual. Atmos. Health* **2016**, *9*, 861–866. [[CrossRef](#)] [[PubMed](#)]
26. Seo, J.Y. The effects of aromatherapy on stress and stress responses in adolescents. *J. Korean Acad. Nurs.* **2009**, *39*, 357–365. [[CrossRef](#)] [[PubMed](#)]
27. Sebastian, L.A.; Kear, T. The Effect of Lavender Aromatherapy on Heart Rate, Blood Pressure, and Perceived Stress Among Cardiac Rehabilitation Patients: A Pilot Study. *Holist. Nurs. Pract.* **2021**. [[CrossRef](#)]
28. Kim, D.S.; Goo, Y.M.; Cho, J.; Lee, J.; Lee, D.Y.; Sin, S.M.; Kil, Y.S.; Jeong, W.M.; Ko, K.H.; Yang, K.J.; et al. Effect of Volatile Organic Chemicals in *Chrysanthemum indicum* Linné on Blood Pressure and Electroencephalogram. *Molecules* **2018**, *23*, 2063. [[CrossRef](#)]
29. Lu, H.; Lyu, X.; Cheng, H.; Ling, Z.; Guo, H. Overview on the spatial-temporal characteristics of the ozone formation regime in China. *Environ. Sci. Process. Impacts* **2019**, *21*, 916–929. [[CrossRef](#)]
30. Brook, R.D.; Rajagopalan, S.; Pope, C.A., 3rd; Brook, J.R.; Bhatnagar, A.; Diez-Roux, A.V.; Holguin, F.; Hong, Y.; Luepker, R.V.; Mittleman, M.A.; et al. Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. *Circulation* **2010**, *121*, 2331–23378. [[CrossRef](#)]