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Indoor Air Quality and Perceived IAQ Symptoms at Small and Medium Food Enterprises in Malaysia

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Abstract
Workers in SME food industries are exposed to emissions from cooking processes that cause adverse health effects. This study evaluated the association of IAQ parameters in SME food industries with perceived IAQ symptoms. The most reported symptoms were fatigue, heavy-headedness, and headache. The study revealed significant associations between CO2 with fatigue symptoms ($p = 0.0340$), temperature with itching or burning eyes ($p = 0.0111$), and humidity with hoarse or dry throat symptom ($p = 0.0013$). The findings underscore the importance of addressing IAQ in SMEs cooking food industries to improve workers' health and working conditions.

Keywords: Indoor air quality; perceived IAQ symptoms; SME food industries; carbon dioxide

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1.0 Introduction

People spend 80-90% of their time indoors rather than outdoors, making indoor air quality (IAQ) a determinant of health and well-being (Saini et al., 2020). According to the United States Environmental Protection Agency (USEPA) (2023), IAQ is the air quality within and around buildings and structures. Over the past century, lifestyle and occupational changes have resulted in individuals now spending a greater proportion of their time indoors compared to outdoors (Paleologos et al., 2021). While the harms of air pollution are well known, only a few are aware that IAQ can be worse than outdoor air quality, posing significant health risks (Mendoza et al., 2021).

In Malaysia, small and medium (SME) food industries represent the second largest contributor to SME activity (Abdul et al., 2017). This industry often involves cooking activities that emit various pollutants by-products such as particulate matter (PM), carbon dioxide (CO2), carbon monoxide (CO), nitrogen dioxide (NO2), and volatile organic compounds which many are toxic and carcinogenic (Zhang et al., 2022; Juntarawijit & Juntarawijit, 2019; Kumar et al.,2023; Pun et al., 2017; Xu et al., 2024). The emission levels of these pollutants are further influenced by ventilation systems, cooking methods, cooking fuels, type of stoves, and the nature of food preparation (Akteruzzaman et al., 2023; Juntarawijit & Juntarawijit, 2019a; Su et al., 2024; Xiang et al., 2021; Kumar et al., 2023; WHO, 2010). Exposure to these pollutants has been linked to adverse health symptoms such as coughing, sore throats, irritated eyes, and shortness of breath, particularly among workers who are working in a high-temperature kitchen environment (Nazli et al., 2023; Parhizkar et al.,

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2023; Svedahl et al., 2020). High-temperature environments can exacerbate the effects, particularly on people with existing respiratory allergic conditions (Lam & Chan, 2019; H. Lee & Yoon, 2024).

The Department of Safety and Health (DOSH) introduced the Industry Code of Practice on Indoor Air Quality (ICOP-IAQ) in 2010 to serve as a reference for the industrial sector in implementing and enhancing the working environment. However, the awareness and implementation of this guideline is somehow low, despite the importance of ventilation in reducing the pollutant exposure (Lee & Aghamohammadi, 2023). Improving IAQ helps to improve worker's health, reduces absenteeism and indirectly improving the economy (Xu et al., 2024).

Despite the growing awareness of the importance of IAQ, there is still insufficient data regarding the exposure towards workers in SME food industries in Malaysia (Nazli et al., 2023). Therefore, this study aims to address this gap by assessing the indoor air quality parameters which include PM2.5, carbon dioxide, temperature, and relative humidity in the SME food industries. Additionally, this study also investigates the associations between the selected IAQ parameters and perceived IAQ symptoms conducted through statistical modeling. Findings from this study will provide valuable insight into the IAQ conditions in SME food industries in Malaysia, providing a foundation for targeted interventions to improve worker health, safety, comfort, and productivity.

2.0 Literature Review

A study by Militello (2018) compared the concentrations of PM2.5 before and during cooking activity while operating mechanical ventilation systems. The study found that the concentrations of PM2.5 had drastically increased after cooking activities were conducted. It was also supported that this pollutant emitted from cooking fumes is further impacted by the presence of ventilation systems such as exhaust hoods (Liu et al., 2021). Cooking activities also emit CO2 (Juntarawijit & Juntarawijit, 2019b; Kumar et al., 2023; Xu et al., 2024; Zhang et al., 2022). The concentration of CO2 further increases when CO emitted during incomplete combustion from cooking or heating using stoves is oxidized to CO2 (Kumar et al., 2023 & Salthammer, 2024).

A study by Svedahl et al., (2020) in Norwegian cooks demonstrates a relationship between the extent of frying and the occurrence of work-related respiratory complaints. About 17.2% of the subjects reported respiratory complaints due to the usage of gas and fryer in the kitchen. Other studies also supported this finding which they found that fatigue, difficulty concentrating, dry throat, tiredness, and dizziness can be associated when exposure to CO2 in the range from 467 to 2800 ppm in an indoor environment (Azuma et al., 2018; Juntarawijit, 2019; Nazli et al., 2023; Wyrwoll et al., 2022). These studies indicate that cooking activities emit pollutants and can cause health problems to the occupants. However, very few studies have been conducted on SMEs in the cooking food industry, and this study aims to further contribute to the existing body of knowledge.

3.0 Methodology

3.1 Study design

This cross-sectional study was conducted in 17 cooking food SMEs located in the northern region of Malaysia. The study consists of three phases: IAQ assessment on selected parameters (PM2.5, CO2, temperature, and relative humidity), questionnaire survey among workers on perceived IAQ symptoms, and data analysis to identify the associations between IAQ parameters and health symptoms among the workers in SMEs food industries.

3.2 Study sample

Respondents of the study were workers involved in cooking activities, including both genders aged 18 to 60 years old, with more than 6 months of working experience.

3.3 Data collection

3.3.1 IAQ parameters sampling

The measurements of the selected indoor air parameters followed standard methods and guidelines from OSHA and ICOP-IAQ 2010. 8-hours IAQ measurements were done at several locations to account for pollutant dispersion using multiparameter equipment with 5-minutes intervals. The measurement was conducted within the sampling area at least 0.5m from corners or windows, walls, and other vertical surfaces, 1 meter away from localised sources, and 1 meter above the ground, following the guideline.

3.3.2 Questionnaire

The European Community Respiratory Health Survey was used to assess the effects on respiratory allergic symptoms among workers, the prevalence of asthma, asthma-like symptoms, and exposure to risk factors. It was a face-to-face interview with the respondents to ensure an optimum response rate.

3.3.3 Data analysis

The statistical analysis of data was performed using R Studio. Descriptive analysis was used to describe the mean and standard deviation of all the variables including the concentration of PM2.5, CO2 and the level of temperature and relative humidity. To examine the association and differences between indoor air pollutant concentrations and the perceived IAQ symptoms among the workers, logistic regression model was performed.

4.0 Results

4.1 Demographic data

Table 1 shows the demographic data of the respondents. A total of 85 out of 91 respondents participated in the study with the highest percentage of age group being 18 to 30 (48.24%), followed by 31 to 40 (22.35%), 41 to 50 (16.47%), and 51 to 60 (12.94%) years old. About 62.35% of the respondents were female while 37.65% were male. Over 90% of the respondents had experience working in SMEs for over 6 months, while 6 respondents (7.09%) had less than 6 months experience. Therefore, 6 respondents were excluded from the study following the exclusion criteria.

Table 1. Demographic data

Demographic characteristic	Age *n* (%)				Gender *n* (%)		Work Experience *n* (%)	
	18-30	31-40	41-50	51-60	Male	Female	< 6 months	≥ 6 months
Total	47 (51.65%)	19 (20.88%)	14 (15.38%)	11 (12.09%)	35 (38.46%)	56 (65.88%)	6 (6.59%)	85 (91.41%)

4.2 Concentration levels for indoor air pollutants across SMEs

This section demonstrated the concentration levels of the selected IAQ parameters. The summary of these results can be seen in Table A1 in the Appendix.

4.2.1 Concentration of carbon dioxide

Figure 1 illustrates the boxplot of CO2 concentrations across the 17 SMEs with the acceptable limit at 1000 ppm by the ICOP-IAQ 2010. CO2 concentrations vary across the SMEs, ranging from a mean of 439.14 (SME 003) to 2220.51 (SME 011). SMEs 001, 003, 004, 005, 006 and 017 maintain CO2 below 1000 ppm. SME 007 has a median close to 1000 ppm, suggesting possible fluctuations above the safe threshold. SME 008 and 012 showed interquartile ranges overlap or close to 1000 ppm, while SME 002, 010, 011, and 014 exceeded the limit. SME 010 and 011 exceeded 2000 ppm with some values reaching 4000 ppm, requiring immediate intervention. The outlier's presence in SMEs 002, 008, and 014 reflects periodic spikes during the cooking process or peak production.

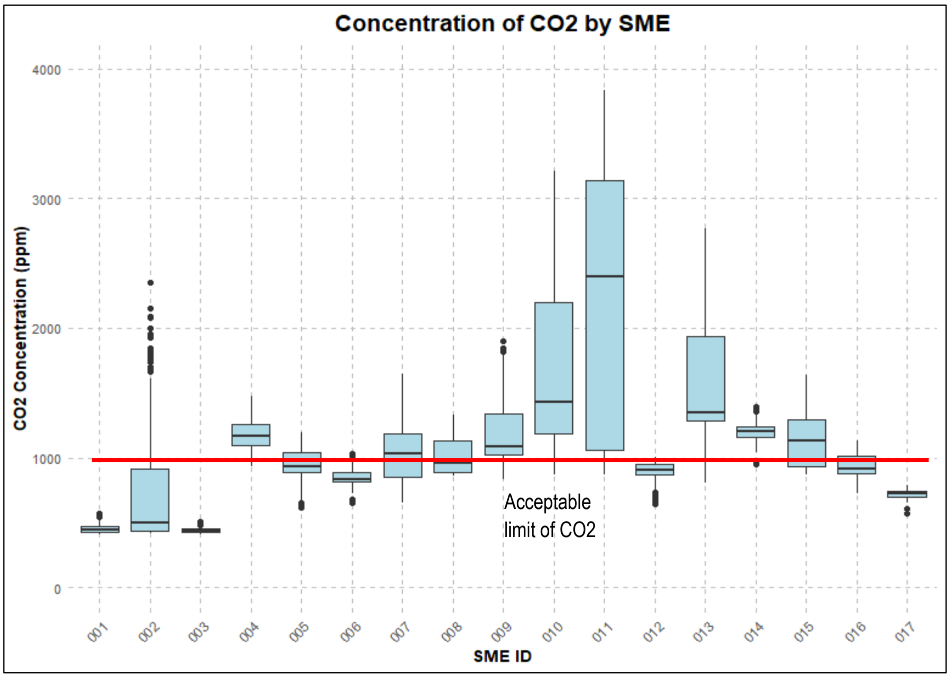

Fig. 1: Concentration of CO_2 by SME

4.2.2 Concentration of PM2.5

The concentration levels of PM2.5 varied widely across the SME with the acceptable limit is 150 µg/m3. SME 003 had the highest mean concentration which exceeded the limit with 204.18 µg/m3. The other four SMEs (003, 004, 006, and 011) also exceeded the acceptable limit. SME 006 had an outlier above 3000 µg/m3, representing periodic spikes from cooking or production processes or machinery.

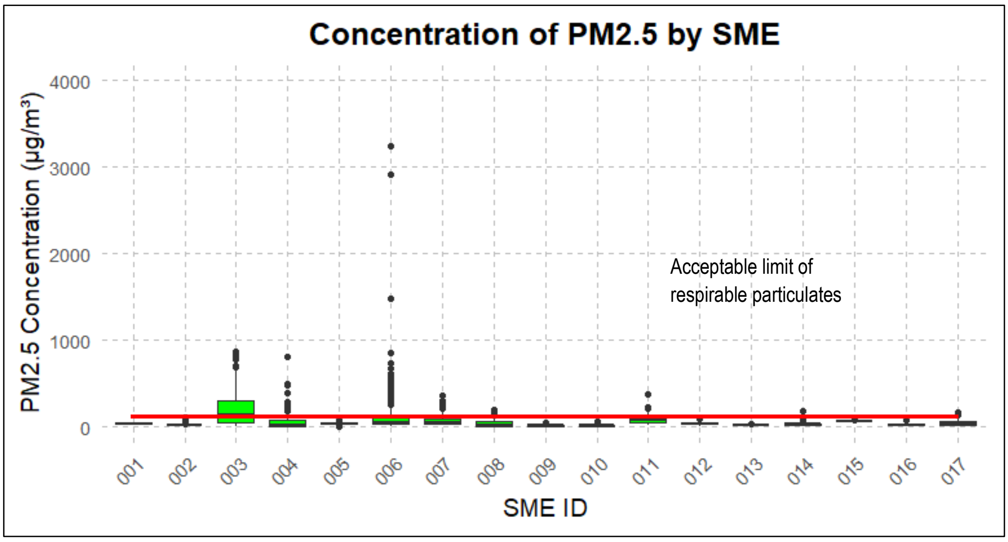

Fig. 2. Concentration of PM2.5 by SME

4.2.3 Temperature level across SME

Figure 3 shows the median temperature level across all SMEs exceeded the recommended range of 23 ˚C to 26 ˚C. Although there was a low standard deviation (Table A1) which indicated that the temperature was stable but elevated conditions, most SMEs recorded temperatures above 30˚C, with none near the acceptable range. SME 002, 003, and 011 reached up to 38˚C, while SME 013 had the lowest median and narrowest range. The outliers indicated intermittent temperature fluctuations, with SME 002 exceeding 40˚C and SME 001 and 003 showing lower outliers around 28˚C, suggesting inefficient temperature control.

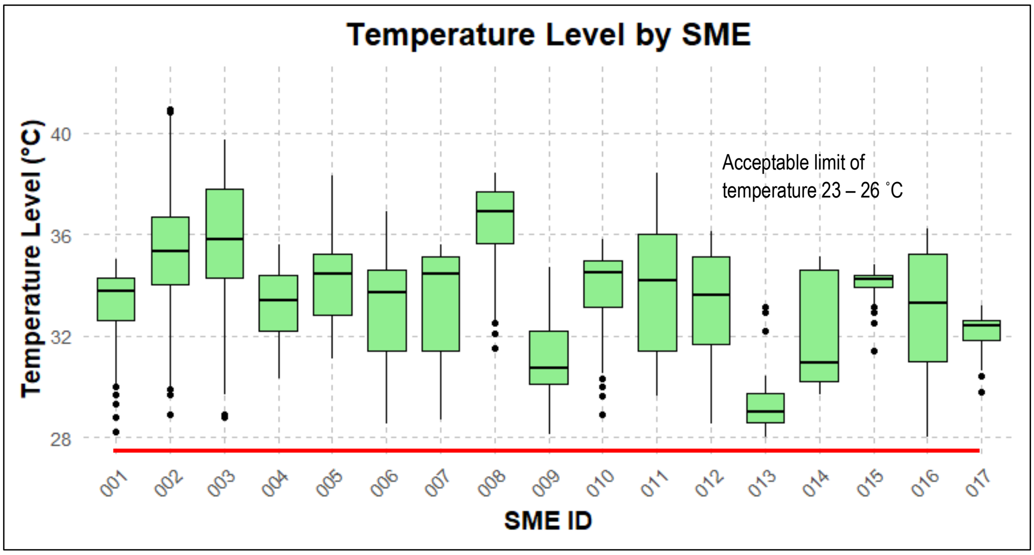

Fig. 3. Temperature level by SME

4.2.4 Relative humidity level across SME

Most SMEs had median values of relative humidity within the acceptable range of 40% to 70%. However, SME 001, 005, 009, and 011 recorded median values near or above the acceptable limit of 70% with distribution exceeding the range at a significant portion. SME 001 and 009 showed persistently high levels of relative humidity, with interquartile ranges and several data exceeding 70%. SME 002, 003, 006, 008, 013, and 015 maintained their humidity levels within the acceptable range, while SME 008 and 016 had median values near the lower acceptable limit of 40%. High variability of relative humidity levels was observed such as in SME 006, 007, and 012 with data points above and below the acceptable range. The high variability may indicate inefficient control or contribution from environmental factors or cooking activities affecting the humidity levels.

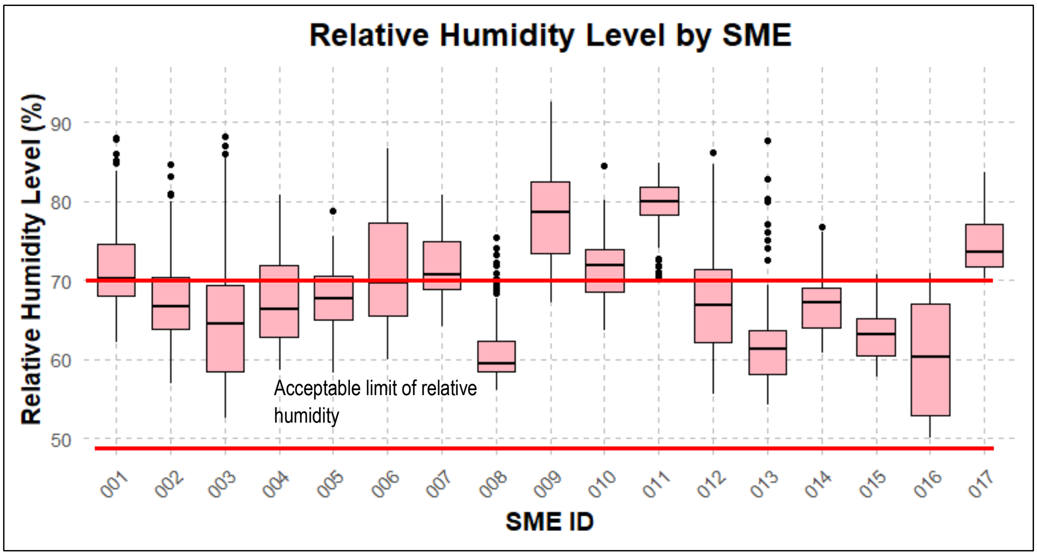

Fig. 4. Relative humidity level by SME

4.3 Prevalence of perceived IAQ symptoms among respondents

Table 2 shows the prevalence of perceived IAQ symptoms among the respondents. Fatigue was the most reported symptom (38.82%), followed by heavy-headedness and headache, 29.41% and 25.88%. Less common symptoms included nausea (1.18%) and difficulties concentrating (2.35%). Symptoms such as itching or burning eyes (9.41%) and stuffy or runny nose (5.88%) were also reported. Hoarse or dry throat affected 24.71%, while 9.41% experienced coughing. Skin symptoms included scaling or itching scalp/ears (25.88%), dry/flushed facial skin (14.12%), and dry, itching, or red hands (4.71%).

Table 2. Prevalence of perceived IAQ symptoms among respondents

Symptom	Response *n* %					
	Yes		No		Don't know	
Fatigue due to work	33	38.82%	52	61.18%	0	0%
Heavy headed due to work	25	29.41%	53	62.35%	7	8.24
Headache due to work	22	25.88%	55	64.71%	8	9.41
Nausea due to work	1	1.18%	75	88.24%	9	10.59%
Difficulties concentration due to work	2	2.35%	74	87.06%	9	10.59%
Itching burning eyes due to work	8	9.41%	73	85.88%	4	4.71%
Irritated stuffy runny nose due to work	5	5.88%	74	87.06%	6	7.06%
Hoarse dry throat due to work	21	24.71%	59	69.41%	5	5.88%
Cough due to work	8	9.41%	69	81.18%	8	9.41%
Dry flushed facial skin due to work	12	14.12%	66	77.65%	7	8.24%
Scaling itching scalp ears due to work	22	25.88%	55	64.71%	8	9.41%
Hands dry itching red skin due to work	4	4.71%	75	88.24%	6	7.06%
Others due to work	24	28.24%	52	61.18%	9	10.59%

4.4 Associations between IAQ parameters and perceived IAQ symptoms

Logistic regression analysis revealed significant associations between measured IAQ parameters (PM2.5, CO2, temperature, and relative humidity) and several IAQ symptoms such as fatigue, itching and burning eyes, and hoarse and dry throat (Table 3). From the results, only CO_2 levels showed a statistically significant association with fatigue ($p = 0.03$, coefficient = -0.0014, OR = 0.9986) while PM2.5, temperature, and relative humidity do not show statistically significant associations with the symptom. Temperature was significantly associated with itching and burning eyes ($p = 0.01$, coefficient = 0.9414, OR = 2.5636), with higher temperatures increasing the odds by 156%. Relative humidity was significantly linked to hoarse or dry throat symptoms ($p = 0.001$, coefficient = -0.1872, OR =

0.8293), with higher humidity reducing the odds of these symptoms by 17%. PM2.5 and temperature showed weak positive associations with dry or flushed facial skin (PM2.5: coefficient = 0.0024, OR = 1.0024; temperature: coefficient = 0.1141, OR = 1.1209), but neither was statistically significant. No significant associations were found between IAQ parameters and scaling or itching of the scalp and ears, with CO2 and PM2.5 showing only weak relationships.

Table 3. Associations of IAQ parameters with perceived IAQ symptoms

Symptoms	Intercept (OR)	CO_2 Estimate (OR)	PM2.5 Estimate (OR)	Temperature Estimate (OR)	Humidity Estimate (OR)
Fatigue	3.0217 (20.53)	-0.0014 (0.9986) *	-0.0043 (0.9957)	-0.1960 (0.8220)	0.0701 (1.0727)
Heavy headed	-7.9432 (0.0004)	0.0002 (0.9998)	0.0032 (1.0032)	0.2017 (1.2235)	0.0099 (1.0100)
Headache	-0.7874 (0.4550)	-0.0010 (0.9990)	0.0178 (1.0180)	0.0188 (1.0189)	-0.0043 (0.9957)
Nausea	2.9031 (18.23)	0.0022 (1.0022)	0.0557 (1.0573)	0.0863 (1.0901)	-0.2347 (0.7908)
Difficulty concentrating	-20.3383 (1.4696^{-9})	-0.0045 (0.9955)	-0.0855 (0.9181)	0.4128 (1.5111)	0.1533 (1.1657)
Itching/ burning eyes	-35.6338 (3.3454^{-16})	-0.0018 (0.9981)	-0.0082 (0.9918)	0.9414 (2.5636) *	0.0601 (1.0619)
Irritated/ stuffy nose	-2.0380 (1.4041^{-9})	-0.0004. (0.9996)	-0.0008 (0.9992)	0.5581 (1.7474)	-0.0067 (0.9933)
Hoarse/ dry throat	16.1663 (1.0494^{7}) *	0.0013 (1.0013)	0.0015 (1.0015)	-0.1954 (0.8225)	-0.1872 (0.8293) **
Cough	10.0311 (2.2722^{4})	-0.0032 (0.9968)	-0.0335 (0.9670)	-0.0095 (0.9906)	-0.1123 (0.8937)
Dry/ flushed facial skin	-1.448 (0.2350)	2.607^{-5} (1.0000)	0.0024 (1.0024)	0.1141 (1.1209)	-0.0617 (0.9401)
Scaling/ itching scalp/ears	-1.8830 (0.1521)	-0.0010 (0.9990)	0.0068 (1.0068)	0.0141 (1.0142)	0.0197 (1.0199)
Hand dry/ itching red skin	-21.1661 (6.4221^{-10})	-0.0018 (0.9982)	0.0045 (1.0045)	0.1947 (1.2149)	0.1922 (1.2119)

*Significant at $p < 0.05$
**Highly significant at $p < 0.01$

5. Discussion

This study assessed IAQ parameters (CO2, PM2.5, temperature and relative humidity) and their associations with perceived IAQ symptoms among workers in SME cooking food industries. The findings revealed significant variability in IAQ parameters across the 17 SMEs, with many exceeding ICOP-IAQ 2010 recommended limits. These results underscore the critical need for better IAQ management in this sector to protect worker health, safety, and comfort.

The concentration levels of CO2 in many SMEs exceeded the acceptable limit of 1000 ppm, with SME 011 recording a mean concentration of 2220.51 ppm which was more than double the threshold. Substantial variability in CO2 levels was also observed in SME 010 and 013, likely due to intermittent cooking activities and ineffective ventilation systems (Akteruzzaman et al., 2023; Juntarawijit & Juntarawijit, 2019b; Sankaran et al., 2023; Xiang et al., 2021). Logistic regression analysis conducted found fatigue, the most reported symptom (38.82%), to be significantly associated with CO2 levels (p=0.03, coefficient= -0.0014). Although the effect size was minimal, this finding suggests that high CO2 concentrations, potentially from inadequate ventilation during intensive cooking activities, contribute to fatigue (Azuma et al., 2018; Militello-Hourigan & Miller, 2018; Wolkoff et al., 2021). Prolonged exposure to high concentrations of CO2 can also impair cognitive functions such as decision-making and problem-solving (Wyrwoll et al., 2022).

PM2.5 levels were generally within acceptable limits (150 µg/m³) across the SMEs, except for SME 003, which recorded a mean concentration of 204.18 µg/m³. This is likely due to frying activities, which are known to emit higher PM2.5 compared to other cooking methods like boiling and baking (Nazli et al., 2023; Su et al., 2024; Xiang et al., 2021). Variability in PM2.5 levels in other SMEs suggests the influence of intermittent cooking or poor ventilation systems. However, PM2.5 was not significantly associated with any IAQ symptoms in this study, consistent with its generally low levels in most locations.

Temperature levels consistently exceeded the recommended range of 23 ˚C to 26˚C at all SMEs except SME 013 and SME 008. Prolonged exposure to high temperatures is known to cause thermal discomfort and related health symptoms. Logistic regression analysis confirmed that temperature was significantly associated with itching and burning eyes (p=0.01, OR= 2.5636), indicating a more than twofold increase in symptom likelihood with higher temperature. While this study only identified an association with one symptom, other studies have suggested that high temperatures can also contribute to headaches, dry and flushed facial skin, and skin irritation (Elser et al., 2021; Fuks et al., 2019, Jiang et al., 2023; Oh et al., 2021; Yadav, 2019).

Additionally, seven SMEs recorded above 70% relative humidity levels, increasing the risk of mold growth and further compromising IAQ. Logistic regression analysis indicates that respiratory symptoms such as hoarse or dry throat were found inversely associated with relative humidity ($p = 0.01$, OR = 0.8293). The results indicate that higher relative humidity levels reduce the symptoms of hoarse or dry throat, suggesting maintaining optimal humidity within the work areas. It is supported that optimal humidity levels between 40-70% are known to support mucociliary clearance, preventing throat irritation and infection (Guarnieri et al., 2023). Similarly, the result also indicated that coughing is negatively associated with humidity levels, although the association was not statistically significant.

The study findings underscore the need to improve the IAQ in SME cooking food industries, particularly by enhancing the ventilation system and regulating thermal conditions in order to protect the health, safety, and well-being of workers in this industry.

6. Conclusion

This study provides insights into IAQ within SME food industries and the associated health risks for workers. Key IAQ parameters often exceeded the ICOP-IAQ 2010 limits, likely due to cooking emissions, poor ventilation, and insufficient thermal comfort control. Prolonged exposure to such environments may lead to adverse health effects. Fatigue, the most reported symptom, was significantly associated with CO_2 levels, which can cause both acute and long-term health impacts. High temperatures were linked to eye irritation, while optimal humidity levels were found to reduce respiratory symptoms like hoarse or dry throat. Improving ventilation and thermal control systems in SMEs is crucial to creating a safer working environment and minimizing health risks for workers.

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Paper Contribution to Related Field of Study

The findings of this study provide valuable insights into the indoor environments of SME food industries and their impact on worker's well-being, contributing to data regarding indoor air quality within Malaysia.

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APPENDICES

Appendix A

Table A1. Statistical summary of indoor air parameters concentration across SME

SME ID	Mean (SD)			
	CO_2	PM2.5	Temperature	Relative humidity
001	453.36 (34.32)	34.80 (6.32)	33.33 (1.39)	71.23 (5.42)
002	707.03 (408.93)	17.59 (11.49)	35.36 (2.31)	67.15 (4.62)
003	439.14 (17.68)	204.18 (196.78)	35.83 (2.46)	64.48 (7.75)
004	1172.92 (118.42)	71.21 (135.87)	33.27 (1.36)	67.32 (5.66)
005	941.82 (135.49)	37.14 (13.86)	34.24 (1.68)	67.45 (4.22)
006	843.47 (58.88)	123.32 (320.50)	33.37 (2.02)	71.25 (7.00)
007	1053.12 (237.50)	71.58 (71.71)	33.61 (1.92)	71.08 (3.90)
008	1016.35 (138.91)	40.85 (48.10)	36.45 (1.61)	61.17 (4.56)
009	1189.59 (240.85)	12.02 (7.98)	30.95 (1.63)	78.00 (5.68)
010	1729.12 (627.98)	11.02 (9.07)	33.91 (1.58)	71.45 (3.63)
011	2220.51 (1018.35)	79.87 (53.48)	34.03 (2.61)	79.41 (3.34)
012	895.55 (72.03)	36.87 (15.02)	33.38 (1.96)	67.44 (7.10)
013	1598.63 (510.48)	14.74 (4.24)	29.00 (0.98)	61.78 (5.80)
014	1187.99 (86.59)	32.26 (21.38)	32.16 (2.11)	66.95 (3.58)
015	1151.53 (214.91)	60.60 (7.89)	34.06 (0.55)	62.90 (2.70)
016	936.96 (85.72)	19.25 (10.35)	32.57 (2.77)	55.75 (8.45)
017	715.71 (41.88)	38.43 (32.33)	32.16 (0.70)	75.03 (3.83)

Appendix B

Table B1. Associations of fatigue with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	3.0217	5.7004	0.530	0.5961	20.5265
Mean CO_2	-0.0014	0.0007	-2.120	0.0340*	0.9986
Mean PM2.5	-0.0043	0.0068	-0.631	0.5278	0.9957
Mean temperature	-0.1960	0.1607	-1.219	0.2228	0.8220
Mean humidity	0.0701	0.0380	1.844	0.0651	1.0727

Table B2. Associations of heavy headed with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	-7.9432	6.5981	-1.204	0.229	0.0004
Mean CO_2	0.0002	0.0007	-0.307	0.759	0.9998
Mean PM2.5	0.0032	0.0084	0.381	0.703	1.0032
Mean temperature	0.2017	0.1856	1.087	0.277	1.2235
Mean humidity	0.0099	0.0410	0.242	0.809	1.0100

Table B3. Associations of headache with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	-0.7874	7.3597	-0.107	0.915	0.4550
Mean CO_2	-0.0010	0.0008	-1.317	0.188	0.9990
Mean PM2.5	0.0178	0.0113	1.583	0.113	1.0180
Mean temperature	0.0188	0.2049	0.092	0.927	1.0189
Mean humidity	-0.0043	0.0436	-0.099	0.921	0.9957

Table B4. Associations of nausea with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	2.9031	29.3988	0.099	0.921	18.2314
Mean CO_2	0.0022	0.0047	0.462	0.644	1.0022
Mean PM2.5	0.0557	0.0632	0.882	0.378	1.0573
Mean temperature	0.0863	0.7868	0.110	0.913	1.0901
Mean humidity	-0.2347	0.3926	-0.592	0.554	0.7908

Table B5. Associations of difficulties concentration with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio

Intercept	-20.3383	43.5727	-0.467	0.641	1.469632e-09
Mean CO2	-0.0045	0.0061	-0.744	0.457	9.954719e-01
Mean PM2.5	-0.0855	0.1474	-0.580	0.562	9.180776e-01
Mean temperature	0.4128	1.2675	0.326	0.745	1.511111e+00
Mean humidity	0.1533	0.1679	0.913	0.361	1.165730e+00

Table B6. Associations of itching and burning eyes with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	-35.6338	16.2853	-2.188	0.0287*	3.3454^{-16}
Mean CO2	-0.0018	0.0014	-1.286	0.1985	9.9812^{-01}
Mean PM2.5	-0.0082	0.0094	-0.878	0.3797	9.9181^{-01}
Mean temperature	0.9414	0.3708	2.539	0.0111*	2.5636
Mean humidity	0.0601	0.1012	0.593	0.5530	1.0619

Table B7. Associations of irritated stuffy nose with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	-2.038^{01}	1.539^{01}	-1.325	0.185	1.4041^{-09}
Mean CO2	-4.103^{-04}	1.557^{-03}	-0.263	0.792	0.9996
Mean PM2.5	-7.664^{-04}	1.179^{-02}	-0.065	0.948	0.9992
Mean temperature	5.581^{-01}	3.906^{-01}	1.429	0.153	1.7474
Mean humidity	-6.683^{-03}	9.870^{-02}	-0.068	0.946	0.9933

Table B8. Associations of hoarse and dry throat with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	16.1663	6.5711	2.460	0.0139*	1.0494^{07}
Mean CO2	0.0013	0.0011	1.192	0.2334	1.0013
Mean PM2.5	0.0015	0.0108	0.142	0.8875	1.0015
Mean temperature	-0.1954	0.1985	-0.985	0.3247	0.8225
Mean humidity	-0.1872	0.0581	-3.220	0.0013**	0.8293

Table B9. Associations of cough with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	10.0311	14.2823	0.702	0.482	2.2722^{04}
Mean CO2	-0.0032	0.0022	-1.461	0.144	0.9968
Mean PM2.5	-0.0335	0.0375	-0.894	0.371	0.9670
Mean temperature	-0.0095	0.3831	-0.025	0.980	0.9906
Mean humidity	-0.1123	0.0684	-1.643	0.100	0.8937

Table B10. Associations of dry flushed facial skin with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	-1.448	7.626	-0.190	0.849	0.2350
Mean CO2	2.607^{-5}	1.003^{-3}	0.026	0.979	1.0000
Mean PM2.5	2.396^{-3}	1.067^{-2}	0.225	0.822	1.0024
Mean temperature	0.1141	0.2202	0.518	0.604	1.1209
Mean humidity	-6.173^{-2}	5.417^{-2}	-1.140	0.254	0.9401

Table B11. Associations of scaling and itching scalp and ears with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	-1.8830	6.9372	-0.271	0.786	0.1521
Mean CO2	-0.0010	0.0008	-1.233	0.218	0.9990
Mean PM2.5	0.0068	0.0090	0.759	0.448	1.0068
Mean temperature	0.0141	0.1937	0.073	0.942	1.0142
Mean humidity	0.0197	0.0414	0.475	0.635	1.0199

Table B12. Associations of hand dry and itching red skin with IAQ parameters using logistic regression model

Coefficient	Estimate	Std. error	Z value	P-value	Odds ratio
Intercept	-21.1661	31.9451	-0.663	0.508	6.4221^{-10}
Mean CO2	-0.0018	0.0016	-1.091	0.275	0.9982
Mean PM2.5	0.0045	0.0162	0.276	0.782	1.0045
Mean temperature	0.1947	0.7366	0.264	0.792	1.2149
Mean humidity	0.1922	0.1659	1.159	0.247	1.2119