

ความรอบรู้ด้านสุขภาพสิ่งแวดล้อมและการป้องกันความเสี่ยงจากเชื้อรา
ในประเทศไทย: ผลกระทบต่อความปลอดภัยด้านอาหารและนโยบายคุณภาพอากาศ
ภายในอาคาร

Environmental Health Literacy and Fungal Risk Prevention in Thailand:
Implications for Food Safety and Indoor Air Quality Policy

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บทคัดย่อ

การปนเปื้อนเชื้อราในอาหารและอากาศเป็นปัญหาสาธารณสุขที่สำคัญ เนื่องจากเสี่ยงต่อการได้รับสารไมโคทอกซินและสปอร์เชื้อราที่อาจก่อโรคทางเดินหายใจและอาการแพ้ ภายใต้สภาพอากาศร้อนชื้นของประเทศไทย การใช้เครื่องปรับอากาศและการเก็บอาหารไม่เหมาะสมยิ่งเพิ่มความเสี่ยง อย่างไรก็ตาม หลักฐานเกี่ยวกับการรับรู้และพฤติกรรมการป้องกันของประชาชนยังมีจำกัด การศึกษานี้มีวัตถุประสงค์เพื่อประเมินระดับการรับรู้ทัศนคติ และพฤติกรรมการป้องกันการปนเปื้อนเชื้อราในอาหารและอากาศของคนไทยอายุ 15-60 ปี และหาปัจจัยที่มีอิทธิพลต่อพฤติกรรมการป้องกัน การวิจัยเชิงพรรณนาแบบภาคตัดขวางในกลุ่มตัวอย่าง 411 คนทั่วประเทศ ดำเนินการด้วยแบบสอบถามออนไลน์ระหว่างเดือนสิงหาคม-กันยายน พ.ศ. 2568 วิเคราะห์ข้อมูลด้วยสถิติเชิงพรรณนาและการถดถอยพหุคูณ ผลพบว่า ผู้ตอบส่วนใหญ่มีระดับการรับรู้ดี (69.83%) ทัศนคติเชิงบวก (67.88%) และพฤติกรรมการป้องกันดี (68.86%) ทัศนคติเป็นปัจจัยทำนายสำคัญที่สุดต่อพฤติกรรมการป้องกัน ($\beta = 0.330$, $p < 0.01$) รองลงมาคือการรับรู้ ($\beta = 0.161$, $p < 0.01$) และอายุ ($\beta = 0.146$, $p < 0.01$) ส่วนเพศ การศึกษา และรายได้ไม่มีความสัมพันธ์อย่างมีนัยสำคัญ สรุปว่า คนไทยส่วนใหญ่มีการรับรู้และพฤติกรรมเชิงรุกในการ

ป้องกันเชื้อรา โดยทัศนคติที่ดีมีบทบาทสำคัญต่อพฤติกรรมการป้องกัน การส่งเสริมสุขศึกษาเพื่อสร้างความตระหนักรู้และทัศนคติเชิงบวกจะช่วยยกระดับความปลอดภัยด้านอาหารและสิ่งแวดล้อมได้อย่างยั่งยืน

คำสำคัญ: การปนเปื้อนเชื้อรา, ไมโคทอกซิน, เชื้อราในอากาศ, การรับรู้ของประชาชน, พฤติกรรมการป้องกัน, ความรอบรู้ด้านสิ่งแวดล้อม

Abstract

Fungal contamination in food and air is a growing public health concern due to exposure risks from mycotoxins and airborne spores that can cause respiratory illnesses and allergic reactions. In Thailand's tropical and humid climate, the widespread use of air-conditioning and improper food storage further elevate fungal exposure risks. However, evidence on public awareness and preventive behaviors related to fungal contamination remains limited. This study aimed to assess awareness, attitudes, and preventive behaviors toward fungal contamination in food and air among Thai adults aged 15–60 years, and to identify key predictors influencing preventive behaviors. A descriptive cross-sectional survey was conducted among 411 Thai adults nationwide using an online questionnaire distributed from August to September, 2025. The instrument covered demographics, awareness, attitudes, and preventive practices. Data were analyzed using descriptive statistics and multiple linear regression to identify predictors of preventive behavior. The results showed that most respondents demonstrated good levels of awareness (69.83%), positive attitudes (67.88%), and good preventive behaviors (68.86%). Regression analysis identified **attitude** as the strongest predictor of preventive behavior ($\beta = 0.330$, $p < 0.01$), followed by **awareness** ($\beta = 0.161$, $p < 0.01$) and **age** ($\beta = 0.146$, $p < 0.01$). Gender, education, and income were not significant factors. In conclusion, the findings reveal high public awareness and proactive behaviors toward fungal contamination among Thai adults. Positive attitudes play a key role in promoting preventive actions. Strengthening health education programs that focus on both awareness and attitude development can further enhance food safety and environmental hygiene practices in Thailand.

Keywords: Fungal contamination, Mycotoxins, Airborne fungi, Public awareness, Preventive behavior, Environmental Health Literacy

Introduction

Fungal contamination in food and air has emerged as a significant global public health concern. Fungi such as *Aspergillus*, *Penicillium*, *Fusarium*, *Mucor*, and *Cladosporium* are ubiquitous environmental organisms capable of producing harmful mycotoxins that compromise both food safety and indoor air quality. In tropical climates like Thailand, where humidity and temperature remain persistently high, these microorganisms proliferate rapidly in poorly ventilated spaces and improperly stored foods. Exposure to fungal spores and their toxic metabolites has been linked to respiratory illnesses, allergic reactions, neurological symptoms, and even carcinogenic effects, particularly from mycotoxins such as aflatoxin and ochratoxin A (A. A. H. Khan & Karuppayil, 2012; R. Khan et al., 2024). Consequently, fungal contamination represents a dual threat to human well-being—affecting both environmental health and food safety systems (Benedict et al., 2016).

Empirical studies in Thailand have confirmed the widespread presence of fungal spores in indoor environments and food storage areas. Narinya et al. (2017) measured airborne fungi in classrooms and laboratories at Khon Kaen University, reporting average concentrations below 500 CFU/m³, which, while within acceptable limits, may still trigger allergic symptoms in susceptible individuals. Similarly, Sriphet et al. (2024) developed an antifungal air filtration system coated with endophytic fungal extracts that effectively reduced airborne spores such as *Penicillium*, *Aspergillus*, *Alternaria*, and *Cladosporium* under controlled environmental conditions, highlighting promising technological measures for indoor air improvement (see also Sánchez–Torres, 2025).

In food systems, the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) have emphasized that Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) form the first line of defense against mycotoxin contamination in cereals, nuts, and dried fruits (FAO & WHO, 2012). Research from the International Commission on Food Mycology (ICFM, 2019) further underscores that improper postharvest handling—especially in high-humidity regions—significantly increases fungal growth and mycotoxin production in food commodities (Liu et al., 2020). Globally, R. Khan et al. (2024) highlighted that up to 25% of global grain products are contaminated with mycotoxins, with chronic exposure linked to liver disease, immunosuppression, and carcinogenesis. These findings align with earlier work demonstrating that inadequate ventilation, moisture, and urban living conditions foster fungal proliferation in indoor environments (A. A. H. Khan & Karuppayil, 2012). Collectively, these studies indicate that fungal exposure in both air and food environments remains an underrecognized but preventable determinant of public health.

Although the scientific understanding of fungal contamination and control technologies has advanced, public knowledge and preventive behaviors remain limited, particularly in Thailand. Previous research has focused primarily on environmental measurement and technological mitigation rather than on human awareness and behavioral adaptation. Given Thailand's humid climate, urban air-conditioning culture, and reliance on stored foods, understanding public risk perception and daily preventive practices is critical. This study adopts the Knowledge-Attitude-Practice (KAP) framework to evaluate how individual awareness and attitudes shape preventive behaviors against fungal contamination in food and air. Such behavioral insights can inform public health campaigns and guide educational interventions aimed at reducing fungal exposure in everyday environments.

While global and regional studies have characterized fungal species and contamination levels, there is a scarcity of data on behavioral and perceptual aspects among the Thai population. Existing research in Thailand has not comprehensively examined how adults perceive risks associated with fungal contamination in food and indoor air, nor has it explored the predictive relationship between awareness, attitudes, and preventive practices. Furthermore, no published survey has integrated environmental exposure awareness with food safety behavior in a single population-based study. Addressing these gaps, the present study aims to (1) assess the levels of public knowledge, attitudes, and preventive behaviors toward fungal contamination among Thai adults aged 15–60 years, and (2) identify key demographic and cognitive predictors influencing protective behaviors. Findings from this study will contribute to evidence-based policy design and community education programs, strengthening Thailand's food safety and environmental health literacy.

Objectives

1. To assess awareness of fungal contamination in Food and Air
2. To examine attitudes toward the prevention of fungal contamination in food and air
3. To study preventive behaviors against fungal contamination in food and air
4. To identify predictive factors of preventive behaviors toward fungal contamination in food and air

Methods

Study Design

A cross-sectional quantitative survey design was employed to assess levels of knowledge, attitudes, and preventive behaviors (KAP) toward fungal contamination in food and air among Thai adults. The design was chosen to capture a snapshot of public awareness and behavioral practices and to identify demographic and perceptual factors influencing preventive actions.

Population and Sampling

The target population comprised Thai citizens aged 15–60 years residing in both urban and suburban areas of Thailand. Participants were recruited using a non-probability purposive and snowball sampling technique to ensure inclusion of individuals from diverse occupational and educational backgrounds. Eligibility criteria included; Thai nationality and residence in Thailand for at least one year; ability to read and understand Thai; and voluntary agreement to participate in the online questionnaire.

A minimum sample size was estimated using Cochran's formula for large populations, with a 95% confidence level and a 5% margin of error, resulting in a required sample of approximately 385 respondents. To increase reliability, 411 completed responses were included in the final analysis after data screening for completeness and validity.

Instrument and Validation

The questionnaire was developed following a literature review and structured into four parts: demographics, awareness, attitudes, and preventive practices. To strengthen content validity, three independent experts in food science, public health, and epidemiology reviewed the instrument, yielding an Item–Objective Congruence (IOC) index ≥ 0.8 , which met recommended standards. A pilot study with 30 participants was conducted to test clarity and reliability. Cronbach's alpha coefficients were calculated, demonstrating acceptable internal consistency ($\alpha = 0.78$ for awareness, 0.81 for attitude, 0.83 for practice). The final instrument comprised 29 items, organized into four sections:

1. Personal Information: Gender, age, education level, and household income.
2. Fungal Contamination in Food and Air Awareness Assessment: 10 multiple-choice questions related to fungal contamination in food and air. Each question had one correct answer, and scores ranged from 0 to 10. awareness levels were categorized as good (8–10), moderate (6–7), or poor (<6).
3. Attitude toward Fungal Contamination in Food and Air Assessment: 5 items measured using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Some items were reverse-scored.

The total score ranged from 5 to 25, and attitudes were classified as good (16–20), moderate (12–15), or poor (<12).

4. Practice toward Fungal Contamination in Food and Air Assessment: 10 items assessed preventive behaviors related to food and air hygiene. A 5-point Likert scale was used, and the total score ranged from 10 to 50. Practices were categorized as good (40–50), moderate (30–39), or poor (<30).

Data Collection and Quality Control

Data were collected over a four-week period (August–September 2025) via a secure Google Forms platform distributed through social media, educational networks, and community groups. Before participation, respondents were informed about the purpose of the study, voluntary participation, and anonymity of responses. Completion of the questionnaire was considered as implied informed consent. To ensure data quality, duplicate responses were automatically restricted, and incomplete forms were excluded from analysis.

Data Analysis

Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize demographic variables and scores for awareness, attitudes, and practices. Multiple linear regression was applied to identify predictors of preventive behaviors. Assumptions for regression—including normality, linearity, homoscedasticity, and multicollinearity—were tested using standardized residual plots, variance inflation factors ($VIF < 5$), and tolerance statistics. Model fit was evaluated through R^2 and adjusted R^2 values, with significance set at $p < 0.05$. Statistical analyses were conducted using SPSS version 26 (IBM Corp., Armonk, NY, USA).

Results

Table 1 presents the demographic characteristics of the 411 respondents who participated in this study. The majority of respondents were female (66.42%), while male participants accounted for 33.58%, indicating higher female participation in the survey. The largest age group was 41–50 years (25.30%), followed by those aged 51–60 years (22.14%) and 31–40 years (19.46%), suggesting that most respondents were middle-aged adults. Only a small proportion were under 20 years of age (14.36%), reflecting limited participation from adolescents.

Regarding educational attainment, almost half of the respondents (48.66%) held a bachelor's degree, and an additional 23.58% had a master's degree or higher, while 27.76% had completed only

high school. This indicates that more than two-thirds of participants possessed higher education (bachelor's degree or above), reflecting a relatively well-educated sample likely to have better access to information on food safety and environmental health.

In terms of monthly household income, most respondents (78.10%) reported earning more than 20,000 THB per month, with the most common income range being 40,001–80,000 THB (26.52%), followed by 20,001–40,000 THB (25.06%). About one-fifth (21.90%) had a monthly income below 20,000 THB. These data suggest that the study sample predominantly represented individuals from middle-income households.

Table 1 Personal data of participants (n=411)

Variable	Frequency (%)
Gender	
Male	138 (33.58)
Female	273 (66.42)
Age	
<15	18 (1.95)
15–20	51 (12.41)
21–30	66 (16.06)
31–40	80 (19.46)
41–50	104 (25.30)
51–60	91 (22.14)
>60	11 (2.68)
Education Attainment	
High school	110 (27.76)
Bachelor Degree	200 (48.66)
Master Degree or above	101 (23.58)
Monthly Household Income (Baht)	
<20,000	90 (21.90)
20,001–40,000	103 (25.06)
40,001–80,000	109 (26.52)
80,001–150,000	62 (15.09)
>150,000	47 (11.43)
Total	411 (100.00)

Table 2 illustrates the distribution of participants' awareness levels regarding fungal contamination in food and air. The majority of respondents (69.83%) demonstrated a high level of awareness, scoring between 8 and 10 on the awareness scale. These participants showed good understanding of fungal sources, contamination pathways, and the associated health effects of exposure to mycotoxins. A smaller proportion (18.25%) exhibited a moderate level of awareness, indicating partial understanding but possible gaps in knowledge about prevention and control measures. Meanwhile, 11.92% of respondents fell into the low-awareness category, reflecting limited familiarity with the risks of fungal contamination and appropriate protective behaviors.

Table 2 Summary: Awareness of Fungal Contamination in Food and Air (n=411).

Number (%)	Percentage	Awareness of Fungal Contamination in Food and Air
287 (69.83)	80–100 (8–10)	Good
75 (18.25)	60–79 (6–7)	Moderate
49 (11.92)	<60 (<6)	Poor

Table 3 presents participants' attitudes toward the prevention of fungal contamination in food and air. The results reveal that a substantial majority (67.88%) of respondents demonstrated a highly positive attitude toward preventive practices, reflecting strong agreement with statements emphasizing the importance of maintaining personal hygiene, ensuring food safety, and promoting clean indoor air environments. This suggests that most participants are aware of their individual and collective roles in reducing fungal exposure.

In addition, 26.28% of participants exhibited a moderately positive attitude, indicating general awareness but possibly limited motivation or confidence to engage in consistent preventive behaviors. Only 5.84% of respondents showed a low level of attitude, implying minimal concern or limited understanding of the importance of fungal contamination prevention.

Table 3 Summary: Attitudes Toward Prevention in Food and Air (n=411).

Number (%)	Percentage	Interpretation of attitude toward fungal contamination in Food and Air prevention
279 (67.88)	80–100 (20–25)	Good
108 (26.28)	60–79 (15–19)	Moderate
24 (5.84)	<60 (<15)	Poor

Table 4 summarizes the preventive behaviors of participants toward fungal contamination in food and air. The findings indicate that the majority of respondents (68.86%) demonstrated good preventive behaviors, reflecting regular engagement in hygienic practices such as cleaning air-conditioning units, maintaining household ventilation, and avoiding consumption of visibly moldy or expired food. These behaviors suggest a strong level of personal responsibility and awareness regarding environmental and food safety measures.

A further 22.14% of participants exhibited moderate preventive behaviors, indicating occasional or inconsistent adherence to recommended practices—such as irregular cleaning routines or limited attention to food storage conditions. Meanwhile, 9.00% of respondents showed poor preventive behaviors, suggesting minimal engagement in fungal prevention activities and limited translation of knowledge and attitudes into action.

Table 4 Summary of preventive behavior toward fungal contamination in food and air (n=411).

Number (%)	Percentage	Interpretation of practice toward fungal contamination in food and air prevention
283 (68.86)	80–100 (40–50)	Good
91 (22.14)	60–79 (30–39)	Moderate
37 (9.00)	<60 (<30)	Poor

Multivariate regression analysis identified three statistically significant predictors of preventive behaviors. Attitude toward fungal contamination prevention emerged as the strongest predictor ($\beta = 0.330$, $p < 0.01$), followed by awareness about fungal contamination ($\beta = 0.161$, $p < 0.01$), and age ($\beta = 0.146$, $p < 0.01$). Gender, education level, and income were not significant predictors (Table 5).

Table 5 Multivariate regression analysis for predictive factor analysis (n=411).

Variable	B	Std. Error	Beta	t	p-value
Gender	0.728	0.764	0.042	0.952	0.341
Age	0.812	0.290	0.146	2.804	0.005
Education Attainment	-1.044	0.627	-0.092	-1.665	0.097

Variable	B	Std. Error	Beta	t	p-value
Monthly Household Income	0.438	0.315	0.069	1.389	0.165
Awareness of Fungal Contamination in Food and Air	0.608	0.192	0.161	3.164	0.002
Attitude toward Fungal Contamination in Food and Air prevention	0.885	0.134	0.330	6.584	0.000

a. Dependent Variable: Practice toward Fungal Contamination Prevention in Food and Air prevention

Discussion

Overall Results

This study investigated public awareness, attitudes, and preventive behaviors toward fungal contamination in food and air among 411 Thai adults aged 15–60 years. The findings revealed a generally positive pattern: most participants demonstrated good awareness (69.83%), positive attitudes (67.88%), and appropriate preventive behaviors (68.86%). Multivariate regression analysis identified attitude as the strongest predictor of preventive behavior ($\beta = 0.330$, $p < 0.01$), followed by awareness ($\beta = 0.161$, $p < 0.01$) and age ($\beta = 0.146$, $p < 0.01$).

These results suggest that increased awareness and positive perception significantly enhance individuals' likelihood of adopting preventive measures against fungal exposure. The overall high KAP levels likely reflect the influence of Thailand's rising educational attainment, public health campaigns, and increased access to digital health information.

Objective 1: To Assess Awareness of Fungal Contamination in Food and Air

A large majority of participants showed high awareness levels, indicating that they understood fungal sources, contamination routes, and associated health risks. This can be attributed to the sample's educational background, where over 72% of respondents had attained higher education, enabling better comprehension of health-related messages. High awareness among educated groups is consistent with the assumption that individuals with more education have greater access to credible health information through academic exposure and online media. These results align with Mukhtar et al. (2023), who emphasized that consumer awareness plays a crucial role in mitigating mycotoxin-related risks in food systems, and Adeyeye (2020), who noted that awareness deficits remain problematic in many tropical regions with lower literacy rates. Similarly, A. A. H. Khan and Karuppayil (2012) identified indoor fungi

as persistent public health threats, particularly when the public underestimates risks from air conditioning and humidity. According to the Knowledge–Attitude–Practice (KAP) model (Launiala, 2009), knowledge forms the foundation for behavior change. The strong awareness observed in this study represents the first stage in the behavioral change continuum, facilitating more positive attitudes and preventive practices.

Objective 2: To Examine Attitudes Toward the Prevention of Fungal Contamination

Approximately two-thirds of participants (67.88%) displayed positive attitudes toward fungal prevention, reflecting widespread recognition of the importance of personal hygiene and environmental cleanliness. Positive attitudes may stem from lived experiences and increased public concern over environmental health and respiratory illnesses, especially in urban settings such as Bangkok. These findings correspond with Viegas et al. (2011) and Méheust et al. (2013), who observed increasing public concern regarding indoor fungal exposure and its health implications. Shiraishi et al. (2023) also highlighted the growing awareness of air conditioner hygiene as a preventive measure against fungal inhalation. The KAP framework conceptualizes attitude as the bridge between awareness and practice, consistent with the theory of planned behavior (Ajzen, 1991). In this study, attitude emerged as the strongest predictor of behavior ($\beta = 0.330$), confirming that individuals who perceive fungal contamination as a serious threat are more likely to act preventively. This pattern aligns with the Health Belief Model (HBM; Glanz et al., 2015), where perceived severity and perceived benefits motivate engagement in protective actions.

Objective 3: To Examine Preventive Behaviors Toward Fungal Contamination

A significant majority (68.86%) of participants engaged in preventive behaviors, such as cleaning air conditioners, improving ventilation, and avoiding moldy food. These practices likely reflect both behavioral awareness and practical accessibility—many participants lived in urban households where air-conditioning and food storage are routine aspects of daily life. This result corresponds with Benedict et al. (2020), who found that public awareness of fungal diseases remains limited and that greater awareness supports the adoption of preventive practices. Shiraishi et al. (2023), Kelkar et al. (2005), and A. A. H. Khan and Karuppayil (2012) also emphasized that regular maintenance of air-conditioning systems reduces fungal growth and spore dispersion, echoing this study’s behavioral findings. Consistent with the KAP model, behavioral change follows cognitive and attitudinal development. Participants with higher awareness and positive attitudes were more likely to translate their understanding into tangible actions, validating the linear relationship proposed by the model.

Objective 4: To Identify Predictive Factors of Preventive Behaviors

Regression analysis identified attitude, awareness, and age as significant predictors of preventive behavior, while gender, education, and income were not statistically significant. Older participants (aged 41–60) likely demonstrated stronger preventive practices due to accumulated health experience and greater concern about disease susceptibility. This trend aligns with Méheust et al. (2014) and R. Khan et al. (2024), who found that health-conscious behaviors increase with age and awareness of environmental hazards. The non-significance of gender or income corresponds with studies showing that fungal exposure risk perception depends more on personal health beliefs than socioeconomic status. Within the KAP framework, attitude functions as a mediating factor between knowledge and behavior—explaining why knowledge alone does not guarantee preventive practice. This study's model supports the sequential pathway (Knowledge → Attitude → Practice), reinforcing its validity in environmental health behavior research.

This study provides evidence that Thai adults generally possess high awareness and positive attitudes toward fungal contamination and engage in preventive behaviors that align with health-protective practices. Education and life experience appear to enhance understanding, while positive attitudes significantly drive behavioral compliance. The findings reinforce the KAP model as a suitable theoretical framework for explaining how cognitive and attitudinal factors predict preventive health behaviors.

The results highlight the need for targeted health education programs focusing on underinformed groups and behavioral reinforcement strategies, such as community workshops, digital campaigns, and home hygiene interventions. Future research should explore longitudinal behavioral outcomes and interventions designed to sustain fungal contamination prevention at both household and policy levels.

Emerging Knowledge

1. Integration of Food and Air Fungal Risk Awareness

This study is among the first in Thailand to integrate public awareness of both foodborne and airborne fungal contamination within a single behavioral framework. The findings reveal that people tend to view fungal risks holistically — associating visible food mold with invisible air contamination — suggesting a cross-domain understanding of fungal exposure. This integrated awareness highlights that food safety and environmental hygiene are interdependent public health concerns rather than separate issues. Fungal risk perception among Thai adults is evolving from isolated food hygiene awareness to a broader, integrated environmental health consciousness.

2. Attitude as the Central Predictor of Preventive Behavior

While knowledge was relatively high, the strongest determinant of preventive behavior was attitude rather than knowledge level. This finding reinforces that behavioral change depends more on perceived importance and personal responsibility than on factual understanding alone. In practice, individuals who *believe* fungal contamination is a serious, controllable threat are more likely to engage in routine preventive actions (e.g., cleaning air conditioners, discarding moldy food). Emotional and perceptual engagement — not just cognitive awareness — drives sustained fungal prevention behaviors.

3. The Maturity of Environmental Health Literacy among Urban Adults

The majority of respondents were urban, middle-aged, and highly educated. Their responses indicate a transition toward environmental health literacy (EHL) — the ability to access, interpret, and act on environmental health information. This reflects Thailand's progress in embedding food safety and environmental hygiene concepts within public discourse and online media. A new tier of health-literate urban citizens is emerging in Thailand, capable of translating fungal risk awareness into preventive practice — signaling readiness for community-driven environmental health initiatives.

4. Behavioral Translation Gap in Middle and Low Awareness Groups

Despite high general awareness, a consistent behavioral translation gap persists among moderate and low-awareness participants (~30%). These individuals possess partial knowledge but lack regular preventive engagement, especially in maintaining air quality or inspecting stored food. This suggests that knowledge alone does not ensure behavioral compliance, confirming the need for motivational and contextual reinforcement (e.g., visual reminders, campaigns, or social norms). Public health strategies must move beyond information dissemination toward behavioral reinforcement and environmental design that make preventive actions habitual and convenient.

5. Validation of the Knowledge–Attitude–Practice (KAP) Model in Environmental Health

The sequential relationship identified — knowledge → attitude → behavior — validates the KAP model in the context of fungal contamination prevention. This supports previous findings in food safety, but with a new application to environmental fungi and air quality. The results confirm that knowledge indirectly influences behavior through attitudes, making attitude a mediating factor between awareness and action. The KAP framework is effective for explaining behavioral determinants of environmental hygiene and can guide public health education models in similar tropical contexts.

6. Age as an Emerging Behavioral Determinant

Older adults (aged 41–60) demonstrated significantly higher preventive behavior scores than younger groups. This suggests a growing age-related health consciousness, possibly due to greater risk perception and accumulated life experience. In contrast, younger adults (15–30) exhibited more

knowledge but weaker behavioral consistency, indicating a generational gap between knowing and doing. Preventive motivation increases with age — highlighting the need for youth-targeted education strategies that make fungal prevention personally relevant and actionable.

7. Toward a Behavioral Ecology of Fungal Contamination Prevention

By linking environmental, food safety, and behavioral dimensions, the study contributes to a behavioral ecology perspective — showing how demographic, perceptual, and environmental factors interact to shape human prevention behavior. This perspective expands fungal contamination research beyond microbiological monitoring toward socio-behavioral determinants, enabling more comprehensive health policy responses. Fungal contamination prevention should be addressed through an interdisciplinary behavioral ecology lens that unites microbiology, environmental health, and public behavior science.

Limitations

This study has several limitations. First, the cross-sectional design does not allow causal relationships between knowledge, attitudes, and preventive behaviors to be established. Second, the use of self-reported online questionnaires may introduce recall bias and social desirability bias. Third, the convenience-based online sampling may limit the representativeness of the sample and affect the generalizability of the findings to the broader Thai population. Finally, the study relied on perceived behaviors and did not include direct environmental measurements of fungal contamination.

Conclusion

This study provides important insights into the awareness, attitudes, and preventive behaviors regarding fungal contamination in food and air among Thai individuals aged 15 to 60. The majority of participants demonstrated a high level of knowledge, positive attitudes, and good preventive practices. Multivariate analysis confirmed that attitudes were the strongest predictor of preventive behavior, followed by knowledge and age. These findings highlight the importance of fostering not only awareness but also favorable attitudes to encourage protective health behaviors.

Given the increasing risk of fungal exposure in urban environments—especially through contaminated food and poorly maintained air-conditioning systems—these results support the need for targeted public health interventions. Educational campaigns should focus on strengthening public attitudes and translating knowledge into consistent behaviors. Furthermore, integrating fungal contamination awareness into food safety and environmental health programs could enhance disease prevention efforts and improve community resilience.

Recommendations

Individual–Level

At the individual level, this study emphasizes the importance of translating awareness and positive attitudes into consistent preventive behaviors. Public education initiatives should therefore focus on promoting practical and actionable habits that can be easily incorporated into daily life. Individuals should be encouraged to regularly clean air-conditioning units, dehumidifiers, and ventilation systems to reduce airborne fungal spores and maintain good indoor air quality. Safe food storage practices should also be emphasized, such as keeping dry goods at humidity levels below 15%, checking expiration dates, and discarding any visibly moldy food to prevent mycotoxin exposure. Additionally, greater awareness of cross-contamination risks in household kitchens, particularly in humid environments, is necessary to minimize fungal growth and spread.

Beyond behavioral actions, individuals should be guided to strengthen their health literacy and critical thinking skills. This includes verifying health information obtained online through credible sources such as the World Health Organization (WHO), the Food and Agriculture Organization (FAO), or the Thai Food and Drug Administration (FDA). Integrating environmental health literacy into daily decision-making—such as monitoring indoor humidity levels or selecting low-risk food packaging and storage materials—can help individuals make more informed and sustainable health choices.

Equally important is promoting attitude-based behavior change, as attitudes have been shown to strongly predict preventive behavior. Public health communication should use social media and community networks to foster positive social norms around fungal prevention, for example through “Clean Air, Safe Food” campaigns. Encouraging emotional engagement by sharing real-life cases of mycotoxin-related illness or allergic disease can enhance personal relevance and risk perception, motivating individuals to act. Furthermore, targeted engagement among youth should be prioritized. Schools and universities should integrate fungal prevention concepts into health education and environmental science curricula, while interactive digital tools and mobile applications can make learning about fungal hygiene more accessible and engaging for adolescents and young adults.

Policy–Level

At the policy level, effective fungal contamination prevention requires a coordinated, multi–sectoral approach that links public health, agriculture, education, and environmental management. Policymakers should integrate food safety and indoor air quality regulations within the same policy framework to reflect the interconnected nature of fungal contamination. National monitoring programs should be established to routinely assess both airborne fungal spores and mycotoxin levels in food markets, schools, and public buildings. These programs would provide essential data for early detection and timely intervention.

To strengthen public engagement, the Ministry of Public Health should lead nationwide environmental health literacy campaigns in collaboration with local health offices, schools, and community leaders. These campaigns should use diverse communication channels—television, radio, social media, infographics, and mobile applications—to disseminate simple, memorable messages focused on “Clean Food, Clean Air.”

Investment in research, innovation, and technology transfer is equally important. The government should support universities and research institutions in developing affordable fungal detection kits, biosensors, and antifungal materials adapted for tropical environments. In addition, the private sector should be incentivized through grants and tax benefits to innovate in air filtration, food packaging, and storage technologies that minimize fungal proliferation.

At the community level, fungal risk surveillance systems should be established. Community health volunteers and local government officers can be trained to identify and report high–risk environments such as markets, food warehouses, and schools. Periodic inspections and hygiene workshops would further strengthen community resilience and long–term behavioral change.

Lastly, the Knowledge–Attitude–Practice (KAP) framework should be formally integrated into health education and public policy evaluation. Using periodic KAP surveys would enable policymakers to assess changes in public awareness, attitudes, and behaviors over time and to evaluate the effectiveness of national health promotion initiatives. Collaboration among ministries of public health, education, environment, and agriculture is essential to create an integrated strategy for fungal risk

management. Public-private partnerships should also be encouraged to promote affordable and sustainable solutions for both food safety and air quality control.

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