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# SUSTAINABLE DESIGN FOR PUBLIC HEALTH: ENHANCING FOOD ALLERGY AWARENESS AMONG THAI UNDERGRADUATES THROUGH ECO-FRIENDLY EDUCATIONAL TOOLS

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## Abstract

Rising food allergy rates across Asia necessitate urgent improvements in campus safety and public awareness. This study addresses this critical public health challenge by evaluating a novel, sustainable design intervention: eco-friendly felt keychains functioning as portable educational tools. Grounded in the Health Belief Model and Experiential Learning Theory, the research aims to enhance allergy knowledge, safety attitudes, and response self-efficacy among Thai undergraduate students. Employing a rigorous mixed-methods pilot design, the study engaged 32 participants in using these biodegradable keychains, featuring iconography for eight prevalent allergens and emergency prompts, over a seven-day intervention period. Quantitative analysis demonstrated a statistically significant improvement in allergy knowledge and a positive shift in safety-oriented attitudes, whereas confidence gains remained non-significant. Complementary qualitative insights revealed high user satisfaction, highlighting the tool's visual clarity and ease of integration into daily life. The study concludes that sustainable, low-cost design interventions can effectively bridge health communication gaps within educational institutions. These findings provide a scalable framework that aligns public health safety with the United Nations' Sustainable Development Goals (SDG 3 and SDG 12) and advocates for the broader implementation of eco-conscious media to cultivate safer, more inclusive campus environments.

**Keywords:** Sustainable Design, Food Allergy Awareness, Health Communication Tools, Mixed-Methods Research, Campus Safety

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## Introduction

Food allergies have emerged as a significant public health issue in recent decades, particularly affecting children and adolescents. Recent estimates indicate that roughly 6-8% of children worldwide have food allergies (Sicherer & Sampson, 2018), with prevalence continuing to rise. In the United States, for example, the rate of childhood food allergies increased by around 50% between 1997 and 2011 (Sicherer & Sampson, 2018). Asia is experiencing similar trends: reported pediatric food allergy rates range from about 1% in Thailand to over 6% in Japan (Lee et al., 2013; Pang et al., 2017). This condition impacts not only the physical health of those affected but also their mental well-being and overall quality of life (Dean et al., 2015). Everyday activities, such as dining out or participating in social gatherings, can induce anxiety and stress for individuals with food allergies, further affecting their psychological health. Insufficient societal awareness and lack of emergency preparedness heighten risks for these individuals, resulting in unnecessary health crises and potential discrimination in both social and educational environments (Knibb et al., 2016; Narissara, 2021). For instance, seafood allergy is a leading cause of food-induced anaphylaxis in parts of Southeast Asia (Lee et al., 2013). However, many communities still lack adequate knowledge and preparedness to handle allergic emergencies (Pang et al., 2017).

Food allergy patterns in Asia differ in important ways from Western settings, with comparatively higher salience of seafood, sesame, and buckwheat, and heterogeneous prevalence across countries and age groups. University campuses in Thailand and the wider region host increasingly diverse student populations—including international students who may face language barriers and unfamiliar food environments—thereby amplifying the risk of inadvertent allergen exposure in cafeterias and informal food stalls (Lee et al., 2013; Leung et al., 2024). In this context, fast, language-light risk communication becomes essential for preventing sentinel events and supporting everyday self-management. Beyond the clinical burden, campus readiness for anaphylaxis remains uneven. Best-practice guidance emphasizes timely recognition of symptoms, rapid access to epinephrine autoinjectors, and clear role-based response pathways; however, translating these expectations to crowded, multi-vendor food environments is non-trivial (Cardona et al., 2020). Interventions that compress critical information into highly recognizable visual cues—paired with brief, on-demand learning—may help shorten time-to-decision and improve bystander assistance during emergencies.

This study responds through a low-cost, portable, and sustainable design intervention: eco-friendly felt keychains that encode common allergens using simple iconography. The approach aligns with the Sustainable Development Goals (SDG 3; SDG 12) by coupling health education with material choices that support reuse and minimize waste. By situating the intervention within Thai university settings, the study adds regionally grounded evidence to a literature base still dominated by Western contexts (Lee et al., 2013; Leung et al., 2024). The combination of rising prevalence and low awareness underscores the need for targeted educational efforts on food allergy safety.

## Literature Review

Food allergies significantly impact the physical and mental health of individuals, affecting their overall quality of life. Raising awareness about food allergies is crucial for reducing risks and enhancing patient safety. Educational interventions effectively improve knowledge, reduce anxiety, and foster supportive environments among young adults managing food allergies. Asia has seen a notable rise in food allergy cases, amplifying the urgency for allergy awareness initiatives in the region. For instance, Pang et al. (2017) reported increased rates of food-induced anaphylaxis in Singapore, while Hu et al. (2010) highlighted that the prevalence among infants in China doubled within a decade. Such data emphasize the critical need for targeted educational initiatives to enhance public awareness and preparedness, particularly

within Asian contexts. Thus, raising food allergy awareness at the community and institutional level remains a global public health priority.

Sustainable design integrates environmental responsibility into health communication tools, aligning public health goals with environmental sustainability. This approach promotes eco-friendly materials, waste minimization, and reusable products, directly supporting the United Nations' Sustainable Development Goals (SDGs), especially SDG 12 (Responsible Consumption and Production). Educational tools, such as eco-friendly allergy-awareness keychains, illustrate this synergy by addressing both SDG 3 (Good Health and Well-being) and SDG 12. These products reduce single-use waste while simultaneously enhancing health education and allergy management awareness. Incorporating sustainable principles into health communication, therefore, not only improves health outcomes but also promotes environmental stewardship.

Compact assistive tools, such as medical alert keychains, effectively convey critical health information during emergencies. Tailored educational tools have significantly reduced stress and increased confidence among people with food allergies. Additionally, portable tools clearly communicate essential allergy information, facilitating rapid response by first responders. Effective communication tools enhance not only physical safety but also psychological well-being. Tangible items such as allergy action plans or keychains significantly reduce anxiety among individuals with food allergies. Portable media promote inclusivity, enabling confident social participation. Moreover, adolescents and young adults, especially in university environments, remain highly vulnerable to severe allergic reactions due to behavioral and lifestyle factors. Introducing sustainable educational media, such as eco-friendly keychains, can serve as visual reminders for allergy management. These tools resonate strongly with young adults' environmental values, aligning effective health communication with sustainability. Consequently, sustainable educational media serve dual purposes, effectively promoting both allergy preparedness and environmental responsibility.

Globally, policy measures and technology-driven programs significantly enhance food allergy prevention. The United States and Canada mandate clear allergen labeling under laws such as the FASTER Act (2021), safeguarding individuals with allergies. In Europe, EU Regulation 1169/2011 mandates transparent allergen labeling, further increasing consumer safety. In Southeast Asia, structured training for restaurant staff in Malaysia significantly improved allergy-handling practices. Furthermore, digital platforms in Europe improved parental preparedness through educational programs and mobile applications. These successful international policies and programs provide adaptable models for enhancing food allergy management in regional contexts such as Thailand.

Food allergy management initiatives align effectively with multiple SDGs. Clear allergen labeling directly supports SDG 3 (Good Health) and SDG 12 (Responsible Consumption). Digital educational tools enhance access to quality education (SDG 4) and promote informed, sustainable consumption. For example, France's allergy programs integrated digital technology with sustainable materials, significantly improving allergy education and anxiety reduction among students. Such integration showcases the value of technology and sustainability in achieving public health goals. Therefore, global allergy initiatives effectively advance public health through alignment with critical SDGs. International best practices provide adaptable frameworks for Thailand. Comprehensive allergy management incorporating eco-friendly media, mandatory allergen signage, supportive digital tools, and consistent staff training could replicate global successes. Aligning these initiatives with SDGs further strengthens their legitimacy and potential impacts, enhancing allergy preparedness and awareness within Thai educational institutions and communities. Thus, adopting integrated global models in Thailand has significant potential to improve public health. This comprehensive review highlights that integrated allergy management programs—comprising clear labeling, sustainable educational

tools, structured training, and digital interventions—significantly mitigate allergy risks. Such holistic approaches yield measurable improvements in knowledge, confidence, and safety. Aligning these practices with SDGs enhances their global relevance, making them critical components of contemporary public health and sustainability strategies.

## **Research Methodology**

### **Study Design and Theoretical Framework**

A single-group pretest-posttest pilot mixed-methods design was employed to evaluate the effectiveness of eco-friendly felt keychains among university students. The intervention is grounded in the Health Belief Model (HBM) and experiential learning theory. Within the HBM framework, the keychains function as "cues to action": heightening perceived susceptibility through visible allergen iconography, increasing perceived benefits via accessible emergency prompts, and lowering barriers through a portable, socially acceptable medium. Consistent with experiential learning, the daily physical interaction with these tools aims to translate abstract safety concepts into practical know-how. Consequently, the study assessed changes in three primary outcome variables: knowledge (cognitive uptake), attitudes (safety orientation), and confidence (self-efficacy).

### **Participants and Ethical Considerations**

Participants consisted of 32 undergraduate students (aged 20-22 years) recruited via purposive sampling based on direct or indirect experience with food allergies. An a priori power analysis (paired-samples t-test,  $\alpha = .05$ , two-tailed, medium effect  $d_z = 0.50$ ) determined that a minimum of 27 participants was required to achieve 80% power. The final sample size ( $n = 32$ ), therefore, provided adequate power for the primary endpoints.

Ethical approval was granted by the Human Research Ethics Committee of King Mongkut's University of Technology Thonburi (KMUTT-IRB-2025/0324/113; approval date: 24 April 2025). Written informed consent was obtained from all participants prior to data collection. To ensure confidentiality, all data were de-identified, stored on password-protected devices, and reported only in aggregate.

### **Intervention Materials**

The intervention utilized eight distinct felt keychains representing prevalent allergens (milk, egg, nuts, seafood, wheat, rice, chocolate, shrimp). Designed to align with sustainability principles, the keychains were produced using biodegradable felt and natural dyes. Each unit featured clear allergen iconography and a concise emergency prompt ("Recognise – Alert – Inject/Seek Care") to facilitate rapid decision-making during allergic reactions.

### **Instruments and Measures**

Quantitative data were collected using four measures:

- 1) Knowledge: 10 items (true/false/not-sure) covering allergens, cross-contact, label reading, and first response.
- 2) Attitudes: 8 Likert-type items (1–5 scale) assessing safety orientation and disclosure willingness.
- 3) Confidence: 6 Likert-type items (1–5 scale) indexing self-efficacy for communication and response.
- 4) Satisfaction: A single global item administered post-intervention to gauge usability.

Items were derived from international guidance and adapted to the Thai context. Content validity was verified by an expert panel comprising an allergy clinician, a health communication scholar, and a design lecturer. Cognitive pretesting ( $n=8$ ) was conducted to ensure semantic and cultural appropriateness, followed by minor wording refinements. All materials were produced in Thai; English-derived items underwent a forward-backward translation process to ensure conceptual equivalence. Post-test reliability analysis indicated acceptable internal consistency for attitudes ( $\alpha = 0.94$ ) and confidence ( $\alpha = 0.95$ ),

while the knowledge index showed reliability adequate for formative composites (KR-20 = 0.22). The full set of quantitative instruments and validation details is available from the authors upon request.

**Procedure**

The study was conducted in four waves (8 participants per wave) to standardize exposure. Participants attended an orientation, completed the pre-test, and were provided with a keychain for 7 days of mandatory everyday use in various settings (e.g., canteens, social events). Following this period, participants completed the post-test, satisfaction survey, and a semi-structured interview to provide qualitative insights into usability and mechanisms of change.

**Data Analysis**

Quantitative data were analyzed using IBM SPSS Statistics (Version 29.0). Pre-post differences were examined using paired-samples t-tests (two-tailed, alpha = .05) after verifying normality via Shapiro-Wilk tests; Wilcoxon signed-rank tests were used where assumptions were violated. Effect sizes were calculated as Cohen’s  $d_z$ .

Qualitative interview data underwent thematic analysis. Two independent coders analyzed 25% of the transcripts, achieving substantial intercoder agreement (Cohen’s kappa = 0.81). Discrepancies were resolved through consensus. The qualitative protocol and complete codebook are available from the authors upon request.

**Research Results**

**Demographic Characteristics**

The final sample consisted of 32 undergraduate students (N=32), predominantly female (62.5%) and aged 20-22 years (75%). Regarding prior exposure to food allergies, 40% of participants reported a personal diagnosis, 30% had a close family member or friend with a food allergy, and the remaining 30% reported no prior direct experience.

**Quantitative Outcomes: Knowledge, Attitudes, and Confidence**

Changes in key outcome variables are summarized in Table 1.

- 1) Knowledge: The intervention yielded a statistically significant increase in mean knowledge scores, rising from  $4.94 \pm 2.06$  at pre-test to  $6.31 \pm 2.09$  at post-test ( $t(31) = 4.10, p < .001$ ). The effect size was large (Cohen’s  $d_z = 0.73$ ), with a 95% confidence interval for the mean difference of [0.69, 2.06].
- 2) Attitudes: Safety-oriented attitudes showed a moderate, significant improvement, increasing from  $3.16 \pm 0.73$  to  $3.62 \pm 0.73$  ( $t(31) = 2.33, p = .026, d_z = 0.41, 95\% \text{ CI } [0.06, 0.86]$ ).
- 3) Confidence: Although self-efficacy scores improved slightly from  $3.28 \pm 0.86$  to  $3.55 \pm 0.82$ , this change did not reach statistical significance ( $t(31) = 1.00, p = .33, d_z = 0.18, 95\% \text{ CI } [-0.29, 0.84]$ ).

**Table 1** Pre-test and post-test scores (N=32)

Construct	Pre-test M ± SD	Post-test M ± SD	Δ (Post- Pre)	t(31)	p	d <sub>z</sub>	95% CI for Δ
Knowledge	4.94 ± 2.06	6.31 ± 2.09	+1.38	4.1	< .001	0.73	0.69 - 2.06
Attitude	3.16 ± 0.73	3.62 ± 0.73	+0.46	2.33	.026	0.41	0.06 - 0.86
Confidence	3.28 ± 0.86	3.55 ± 0.82	+0.28	1	.33	0.18	-0.29 - 0.84

Note: Knowledge = 10 binary items (KR-20 = 0.22); Attitudes = 8 Likert items ( $\alpha = 0.94$ ); Confidence = 6 Likert items ( $\alpha = 0.95$ ). Δ = mean difference;  $d_z (= t/\sqrt{n})$

**Participant Satisfaction and Usability**

Post-intervention feedback indicated high levels of acceptability. A substantial majority of participants (87.5%) rated their experience with the keychain as “Satisfied” (25.0%) or “Very Satisfied” (62.5%), with only a small fraction expressing neutral (6.3%) or dissatisfied (6.3%)

sentiments. Participants specifically highlighted the clarity of the allergen symbols and the utility of the built-in emergency prompt as key strengths.

### **Qualitative Insights**

Thematic analysis of semi-structured interviews (n = 32) identified four recurrent themes regarding the tool's impact and usability:

- 1) Ease of Use (mentioned by 31.3% of participants): Highlighting the portability and convenience of the design.
- 2) Clarity of Information (25.0%): Praising the distinct iconography.
- 3) Increased Awareness (21.9%): Noting that the tool served as an effective visual reminder.
- 4) Suggestions for Improvement (15.6%): Recommending enhanced material durability and options to customize emergency contact details.

Detailed illustrative quotations and the complete coding frequency matrix are available from the authors upon request.

### **Conclusion and Discussion**

This study shows that a simple, portable, and eco-friendly visual cue—felt keychains with standardized allergen iconography—was associated with clear gains in university students' food-allergy knowledge and safety-oriented attitudes. These patterns converge with campus evidence that young adults frequently under-avoid allergens, inconsistently carry epinephrine, and benefit from tailored supports embedded in daily routines. The direction and magnitude of change observed here are therefore consistent with known readiness gaps in tertiary settings, where autonomy increases faster than institutional safeguards. Positioned in Asia, the findings speak to regional dining and allergen profiles. Comparative reviews indicate that shellfish and seafood exposures feature more prominently in several Asian populations, while communal, shared-dish eating increases cross-contact risk. Thai data further document clinically relevant food-allergy burdens and temporal increases in younger cohorts, underscoring the need for scalable tools as students transition to university life. The icon-based, bilingual keychains used here respond directly to those patterns by enabling recognition and disclosure to be fast, culturally legible, and socially acceptable in canteens and student events. Mechanistically, the intervention likely functioned as a persistent “cue in context” that lowers the social cost of disclosure, normalizes ingredient inquiry, and prompts avoidance planning at the point of choice. This logic aligns with contemporary specialty guidance that places education, individualized avoidance strategies, and emergency preparedness at the core of food-allergy management across everyday settings, including campuses.

In practical terms, universities can amplify impact by harmonizing allergen iconography across menus and event signage, attaching QR micro-lessons to keychains (e.g., steps for cross-contact prevention and emergency response), and training dining-service partners to respond consistently—an approach that aligns with priorities highlighted in campus-focused studies. The observed gains in knowledge and confidence should be interpreted as precursors to behavior change on campus. Students who can rapidly identify their allergen class and communicate it with a standardized icon are more likely to disclose needs to vendors, check ingredient lists proactively, and enlist peers during prospective reactions. When paired with concise QR-linked micro-lessons on symptom recognition, cross-contact avoidance, and the timing/use of epinephrine, such tools may shorten decision latency and improve first-response quality in real-world incidents.

For scale-up in Asian universities, a four-pillar model is feasible: 1) icon harmonization for a core set of allergens with bilingual labels; 2) micro-lessons (30-60 s) accessible via QR on keychains and at points-of-sale; 3) vendor and peer training focused on cross-contact prevention and role clarity during emergencies; and 4) campus readiness measures (visible epinephrine access where legally feasible and symptom posters). Key performance indicators

include accuracy in allergen identification, intention to disclose, access to or carriage of epinephrine, time-to-help, and near-miss reporting; the model is adaptable to local cuisines and aligns with guideline-consistent response pathways. Sustainability considerations warrant explicit planning. Compared with single-use pamphlets, durable felt artifacts can be repaired (e.g., by replacing rings or stitching), refreshed annually through small-batch rebranding, and collected at the end of life through take-back. Future work should quantify environmental and cost trade-offs between reusable keychains and print campaigns while tracking educational outcomes, enabling universities to advance SDG targets without compromising safety or pedagogical impact. Beyond statistical significance, the gains suggest that students are better prepared to disclose allergens, read labels proactively, and coordinate peer assistance in the shared-dish settings typical of Asian campuses. Embedding bilingual iconography across canteens and QR-linked 60-second micro-lessons aligns with SDG 3 and SDG 12 while imposing minimal operational burden, offering a scalable pathway for Thai universities to strengthen campus safety and material stewardship. Finally, the intervention couples health communication with material stewardship: using durable, biodegradable felt and a reusable format links student safety to responsible consumption practices already championed on many Asian campuses. While the present study did not directly measure environmental outcomes, this design choice is congruent with the broader sustainability remit of university policy and procurement and positions the tool as a low-cost adjunct to existing student-health and sustainability programs.

Regarding limitations and future research, this single-site pilot used short follow-up and self-report instruments, which constrain behavioral inference. Although the direction of effects aligns with campus literature, future studies should: (i) extend follow-up to test durability; (ii) include objective endpoints (verified epinephrine carriage, observed disclosure, label-reading accuracy); (iii) examine heterogeneity by prior allergy experience and international-student status given Asian dining norms; and (iv) evaluate implementation packages that pair keychains with menu iconography and staff training mapped to guideline recommendations. Multi-site trials across Thai and regional universities are warranted to benchmark outcomes against national trends and contextual prevalence reports.

Based on these findings, several recommendations are proposed. Regarding Practice and Policy, institutions should scale opt-in keychains or cards across faculties and dormitories; co-deploy bilingual, QR-enabled variants; pair roll-out with vendor training and standardized iconography to harmonize signals across canteens; and embed sustainability via durability specifications, local materials, and repair/take-back programs. For Implementation in Thailand, identifiers should be integrated into first-year orientation and LMS; a QR landing page with emergency steps and campus contacts should be provided; and an allergy registration pathway tied to health-and-safety protocols (including epinephrine access and EMS activation) should be created. Regarding Research, future work should conduct adequately powered multi-site trials across Thai regions and neighboring countries; extend follow-up to 3-6 months; add objective behavioral metrics and scenario-based assessments; compare arms (icon-only vs bilingual+QR) to isolate information-depth and language-access effects; evaluate cost-effectiveness and supply-chain sustainability (local sourcing, repairability); and finalize item banks with improved discrimination and documented psychometrics.

In conclusion, in a Thai university context, eco-friendly felt keychains operated as practical, daily-use cues linked to brief learning and were associated with measurable improvements in food-allergy knowledge and safety-oriented attitudes. The pattern aligns with campus studies documenting young-adult risk behaviors and the value of targeted supports, and it aligns with contemporary guideline pillars of education, avoidance planning, and emergency readiness. Situated within Asian dining cultures and national prevalence trajectories, the intervention is a low-cost, sustainable adjunct to university allergy-safety ecosystems. Scaling should prioritize

harmonized iconography, QR-based micro-lessons, and coordinated training with dining partners, while future research confirms durability and behavioral impact across diverse campuses.

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