A User-Centered Design for Food Allergy Alert System: Enhancing User Safety and Usability

Nabin Prasad Dhakal, Nischal Karki, Dr. Sushil Shrestha
Department of Computer Science and Engineering (DOCSE), Kathmandu University
{nd16041720, nk23041720}@student.ku.edu.np sushil@ku.edu.np

***Abstract*—Introduction: Food allergies affect over 10% of the global population, with no cure available. This study explores the development of a Food Allergy Alert System for food delivery applications to enhance user safety.**
Related Works: Previous solutions include barcode-scanning apps and prototypes providing allergen information, but many require improvements in quality and usability.
Methodology: A mixed-methods approach was used, combining surveys, prototype testing, and user feedback. Participants from diverse backgrounds were selected, and the system's usability was measured using the System Usability Scale (SUS) and Task Success Rate.
Design Implementation: The system incorporates features such as allergen input, toggle filters, warning tags, and confirmation dialogs. Design principles focused on accessibility, usability, and customization.
Testing and Results: Usability testing indicated strong user satisfaction, with a SUS score of 85.7 and a task success rate of 90% for Design B. Post-survey feedback confirmed the system's effectiveness in enhancing user safety and allergen management.
Conclusion: The Food Allergy Alert System demonstrates potential to significantly improve safety and user experience in food delivery applications for individuals with allergies, though further research with larger populations is recommended.

***Index Terms*—Food Allergy Alert System, Food Delivery Application, User-centered Design, User Safety, Usability testing, allergen**

I. INTRODUCTION

Food hypersensitivity (FH) has become a significant global health concern, affecting more than 10% of the general population. Food allergies, a common type of FH, are estimated to impact approximately 1 in 10 adults and 1 in 12 children [10]. Despite extensive research efforts, there is currently no cure for food allergies; thus, avoiding allergens remains the primary management strategy to prevent allergic reactions, including anaphylaxis, a potentially life-threatening response. The prevalence of food allergies and anaphylaxis is rising significantly worldwide, making this issue increasingly important [6]. Traditional solutions, such as food labeling, have been the primary method for managing food allergies but have shown limited effectiveness. Consequently, there is a need for more effective and innovative solutions to address this challenge.

Technological advancements in the health industry have recently gained significant attention, particularly with the rise of digital health technologies. The integration of these technologies into the health system is increasing, offering new opportunities for managing food allergies [5]. Numerous mobile phone applications (apps) designed for food allergies and intolerances are available in app stores, providing various tools to help individuals manage their dietary restrictions. However, these apps as per the Mobile App Rating Scale (MARS) quality, especially those related to restaurant dining, require enhancements to improve their qualitative and quantitative qualities. [7].

In this research study, we will examine several aspects related to food allergies, including relevant literature on food allergy management, existing works in the field, methods for gathering information about food allergy issues from the perspective of potential users, the implementation of solutions to address these challenges, and explore usability testing to assess the effectiveness and user-friendliness of these solutions.

II. RELATED WORK

The study of food allergy problems and the development of technological solutions cover a wide range of topics. These include software-related solutions from software engineering and algorithm implementation perspectives, as well as technological innovations focused on creating devices and tools. Numerous applications available in app stores aim to address food allergy issues by providing functionalities that help individuals with food allergies make safe choices among available products. Common features in these apps include barcode-scanning capabilities to display ingredient lists and filters to sort foods based on the presence of specific allergens.

In the paper by Sutrisno, Yulianti, and Harlili (2021), they demonstrated a technological solution for food allergy management. The application prototype provided food allergy information using a user-centered design approach within the context of the Gojek platform. It helped users by offering an intuitive interface to access detailed information about food allergens. By incorporating user feedback into the design process, the app ensured that the information is easily accessible and useful for individuals with food allergies, enhancing their ability to make informed food choices [9]. A similar work by Grifantini (2016) in her paper is 'ipiit', an application launched by San Francisco-based co-founders that help the users search for any potential allergens in the products they are about to buy and suggest alternative products based on their personal preferences [2].

III. Literature Review

A. Food Allergy

A food allergy occurs when the immune system overreacts to certain foods, potentially causing symptoms like dizziness, hives, swelling, difficulty breathing, nausea, and diarrhea. Severe reactions can include swelling of the throat, difficulty breathing, and fainting, requiring immediate medical attention and the use of an adrenaline auto-injector such as an EpiPen. Common allergens include milk, eggs, peanuts, tree nuts, shellfish, and wheat. Diagnosis often involves skin-prick tests, blood tests, and dietary monitoring. Managing food allergies includes avoiding trigger foods, reading labels, informing others, and carrying emergency medication [1].

B. Design Principles

Design principles are crucial guidelines for developing user interfaces that improve usability, accessibility, and user satisfaction. Ben Shneiderman's book "Designing the User Interface" outlines key principles such as consistency, feedback, error prevention and handling, user control and flexibility, aesthetic and minimalist design, and accessibility. Consistency ensures uniformity in visual elements and behavior, reducing cognitive load. Providing immediate, informative feedback keeps users aware of their actions, while proactive error prevention and supportive error handling assist users in recovering from mistakes. Empowering users with control and customization options accommodates various preferences and skill levels. A clean, minimalist design enhances clarity and directs attention to essential features, improving efficiency [8].

C. Guidelines, Principles, and Theories

In "Designing the User Interface", Ben Shneiderman outlines a comprehensive framework for creating effective and user-friendly interfaces, grounded in guidelines, principles, and theories. Shneiderman's guidelines offer practical advice for achieving consistency, providing immediate feedback, preventing errors, and maintaining user control and freedom. His principles, derived from cognitive psychology and human-computer interaction research, emphasize consistency, the provision of shortcuts for expert users, informative feedback, dialog design that provides closure, and error prevention. Underpinning these guidelines and principles are theories such as Cognitive Load Theory, which stresses the importance of minimizing unnecessary cognitive effort, Gestalt Principles, which explain how people perceive visual elements as unified structures, and Fitts's Law, which predicts the time required to move to a target based on its size and distance. By integrating these elements, Shneiderman's approach ensures the development of user-centered, intuitive, and efficient interfaces that enhance usability and user satisfaction [8].

D. Managing Design Process

Managing the design process, as detailed by Ben Shneiderman in "Designing the User Interface", emphasizes a structured, iterative method that prioritizes user-centered design and usability. This process begins with organizational design to ensure that usability is supported by establishing appropriate structures and teams within organizations. It includes adherence to the three pillars of design: guidelines that ensure consistency and usability, tools that facilitate effective design and testing, and expert reviews that provide critical feedback early in the design process. Development methodologies such as agile are adopted to allow flexibility and continuous improvement through iterative cycles, supporting rapid prototyping and frequent user feedback. Ethnographic observation and participatory design are essential for gaining deep insights into user behavior and involving users directly in the design process, ensuring the final product aligns closely with user expectations. Scenario development helps envision user interactions and anticipate issues, while iterative design and prototyping involve repeated cycles of designing, testing, and refining the interface based on user feedback. User-centered design places user needs, preferences, and limitations at the forefront, achieved through interviews, surveys, and usability testing [8].

E. Evaluating Interface Design

Evaluating interface design is essential to ensure usability and effectiveness. In "Designing the User Interface," Ben Shneiderman outlines several evaluation approaches. Heuristic evaluation involves experts reviewing the interface against usability principles, like error prevention and system visibility, to spot issues. The System Usability Scale (SUS), a ten-item questionnaire, provides a quick measure of perceived usability [4], while the Task Success Rate assesses how effectively users complete tasks. User testing gathers data from real users on task completion, errors, and satisfaction. Cognitive walkthroughs help evaluators simulate new user interactions, identifying potential challenges and cognitive mismatches. A/B testing compares two interface versions to see which performs better in terms of user engagement and success. Additionally, analyzing user interaction data through metrics and analytics helps uncover patterns, errors, and abandonment points, guiding improvements to the design. These methods together provide a comprehensive understanding of the interface's usability [8].

IV. Methodology

A. Participants

Participants in this research study were selected from an age group below 55, representing various professions and backgrounds, in an effort to maintain diversity while controlling the testing environment. We classified responses based on age, gender, and professional experience, allowing us to gather constructive feedback and suggestions related to specific system features from both novice and expert users. This structured approach helped us determine which features to enhance, remove, or modify, making the process more user-friendly and interactive. Through the survey, we gathered 101 responses, with 79 males and 22 females, from participants aged between 18 and 55 years. Most respondents (76%) were in the 18-35 age range, which allowed us to capture detailed feedback on system usability. For the in-person prototype testing, we involved 18 individuals—10 males and 8 females—ensuring a balanced representation. A/B testing was conducted in four groups of 2 people each: each group having 1 male and 1 female. All testing sessions took place within the controlled environment of the Digital Learning Research Lab to ensure consistency. This approach allowed us to gather precise, constructive feedback, which was incorporated into our final design.

B. Research Design

Our study employed a mixed-methods research design, integrating both qualitative and quantitative approaches to evaluate the user experience and feasibility of an allergy warning system in food delivery applications. Following the principles outlined by Ben Shneiderman in Designing the User Interface, we adhered to user-centered design methodologies, ensuring the process was iterative and inclusive of user feedback. The study was structured around pre-survey and post-survey phases, with the pre-survey capturing baseline data and the post-survey evaluating user responses to a video demonstration of the prototype system.

C. Data Collection

Data collection was designed to gather comprehensive insights while adhering to Shneiderman's design principles, guidelines, and theories. We employed both Agile and Waterfall methodologies for survey data collection. In the pre-survey, participants answered multiple-choice questions about their user profile, habituality with online food delivery, knowledge and experience with allergies, and their current management strategies for allergies while ordering food online. This phase was critical in understanding the initial user context, which aligns with Shneiderman's emphasis on gathering user background and preferences to inform design decisions. During the post-survey phase, participants watched a detailed video demonstration of the prototype allergy alert system. This approach allowed us to control the presentation of the system's features, ensuring consistency in the user experience being evaluated. The post-survey included multiple-choice questions focusing on several key areas:

1) User Experience with the Prototype: Assessing how users perceived the prototype's usability, effectiveness, and overall satisfaction. We employed participatory observation, mutually cooperating with each other through sessions and taking necessary feedback and making necessary changes to ensure user satisfaction. Additionally, we developed personas to understand how different types of users—such as those with physical variations, cognitive and perceptual variations, diverse personalities, cultural and international diversity, users with disabilities, the elderly, and children—interacted with the system.
2) Feasibility of Allergy Recommendations: Evaluating whether users found the allergy alert system practical and useful for making informed decisions about food orders. This is in line with Shneiderman's guidelines on error prevention and providing informative feedback.
3) Design Perspective: Gathering user feedback on the design elements such as the placement of allergy warnings, alerts, and dialogs. This evaluation incorporates Shneiderman's design principles, including consistency, aesthetic and minimalist design, user control, and less cognitive load.
4) User Recommendations: Collecting suggestions from users on how to improve the system. This participatory approach reflects Shneiderman's emphasis on involving users in the design process through iterative feedback loops either from survey using Agile Methodology or from active participation sessions through Participatory Observation.

For in-person prototype testing, we employed a 10-question System Usability Scale (SUS) with a 5-point Likert scale to assess user experience, providing structured quantitative insights. We tested for both low-fidelity and high-fidelity prototype for Design B. Additionally, A/B testing was conducted to compare two system versions: Design A for two groups and Design B for next two groups, with the task success rate serving as a key metric for evaluating usability. Participants were tasked with five tasks. (i.e., searching for allergy information, changing the sensitivity of the allergen, toggling the allergen filtration button, adding allergy preferences, placing an allergy-safe order). Each task was credited 10 points. The task success rate measured the percentage of users (out of 50 points) who completed these tasks accurately ensuring a robust evaluation of the design's effectiveness and efficiency.

D. Ethical Consideration

Ethical considerations were integrated throughout the study, ensuring compliance with standards for research involving human participants. Participants were fully informed about the study's objectives, procedures, and their rights, including the right to withdraw at any time. Informed consent was obtained prior to participation. Data privacy and confidentiality were strictly maintained, with all personal identifiers removed to ensure anonymity.

E. Limitation

Several limitations were acknowledged in this study. The sample size, while adequate for initial testing, may not be representative of the broader population, limiting the generalizability of the findings. The use of a video demonstration instead of direct interaction with the prototype may not fully capture the nuances of user experience during online survey. Additionally, reliance on self-reported data in multiple-choice questions introduces potential biases such as social desirability bias and recall bias.

V. Design Implementation

A. Feature Analysis

In our feature analysis, we used insights from user surveys and personas to guide the development of system features. Through research, we identified user preferences and pain points related to allergen management. This informed the creation of personas representing different user groups, ensuring our design decisions were grounded in real user needs. The features developed for the system are listed in the following table:

TABLE I: Features of the System

S.No	Feature Name: Description
1	Allergen Input: Allows users to input their allergens into a dedicated drawer within the application.
2	Toggle Filter Button: A button on the homepage enables users to switch allergen alerts on or off, ensuring customizable visibility.
3	Warning Tags: Each food item card includes warning tags indicating the presence of allergens, enhancing user awareness.
4	Allergen Sensitivity: Features a sensitivity adjustment setting categorizing allergens by risk level, providing customizable alerts.
5	Warning Texts: Detailed information accompanies allergen alerts, offering insights into allergen risks.
6	Confirmation Dialog Box: Prompts users to confirm their decision when attempting to order food with allergens, preventing accidental orders.

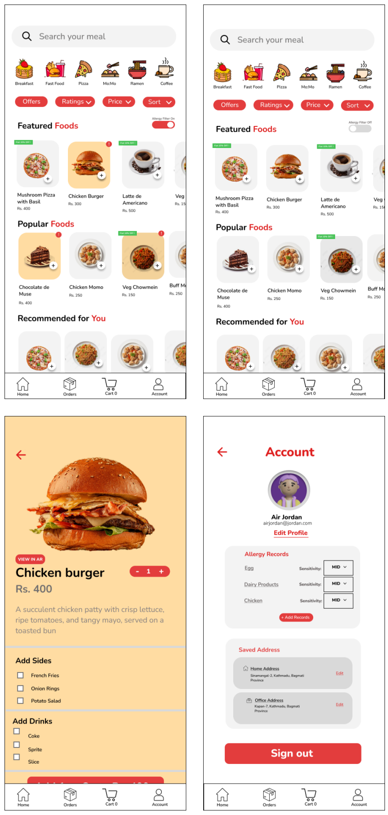

Fig. 1: Prototype (Design B) Demo Images I

B. Design Principles

The system design ensured accessibility, usability, flexibility, safety, and customizability by adhering to key design principles. Visibility was achieved through the clearly labeled allergen drawer and prominently placed toggle filter button, making features easily visible. Feedback was provided via color-coded warning tags and post-order allergen alerts, offering immediate visual and real-time confirmation as shown in. Constraints were incorporated through the alert dialog box, which required user confirmation to proceed with an order containing allergens, minimizing user errors. Mapping was demonstrated by the direct association between input fields (allergen input) and outcomes (allergen management), as well as the toggle filter button's on/off states corresponding to allergen alert visibility. Consistency was maintained through the logical categorization of allergens into high-risk and mild categories and the use of universally relevant icons, ensuring uniformity across the interface. Affordance was evident in the design of the toggle filter button and the alert dialog box, suggesting their functionalities naturally as shown in figure(2).

C. Eight Golden Rules for Interface Design

Shneiderman's 8 Golden Rules of Interface Design were incorporated in the design to ensure an accessible, usable, flexible, safe, and customizable user experience. Consistency was maintained through uniform

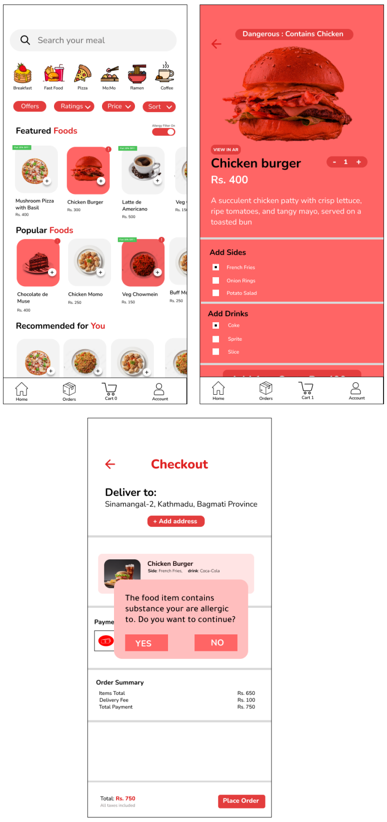

Fig. 2: Prototype (Design B) Demo Images II

warning tags and color coding across all food item cards, making allergen information easily recognizable as shown in figure. Experienced users benefited from shortcuts such as the toggle filter button, which streamlines allergen alert management. The system provided informative feedback through visual cues and post-order dialog boxes, keeping users informed about potential risks. Dialogs were designed to yield closure, with the post-order allergen alert prompting users to make decisions, ensuring they are aware of any risks. Error prevention was facilitated by allowing users to input allergens and set sensitivity levels, with an additional safety net provided by the post-order alert. The system supported easy reversal of actions through the toggle filter button, while customizable settings for allergen sensitivity and specific allergen input gave users control over their experience. Warning tags, color coding, and immediate feedback reduced cognitive load, helping users process information quickly without relying on short-term memory. The design further implemented heuristic principles by applying associative linkage in the allergen filter, enabling seamless switching between allergen-prevalent and non-allergen-prevalent foods, and referential indications such as warning tags and alerts to notify users of specific allergen-containing items, refining the overall usability and safety of the system.

D. *Guidelines and Theories*

1) GOMS and CMN-GOMS: GOMS (Goals, Operators, Methods, and Selection rules) and CMN-GOMS (Card, Moran, and Newell's GOMS) theories were integrated into our system design to analyze and predict user interactions. Goals focused on efficient allergen management, with Operators responsible for tasks such as inputing allergens, toggling filters, and confirming alerts. Methods outlined user workflows, including accessing allergen information and adjusting sensitivity settings. Selection Rules guided the choice of methods based on context, such as using the toggle filter for quick allergen checks. Visibility and feedback mechanisms were designed to enhance user understanding, with clear buttons and labeled drawers facilitating ease of use. Features like the toggle filter and alert dialog streamlined processes, improving overall system efficiency. Constraints, such as confirmation prompts in the alert dialog, ensured adherence to proper sequences, reducing errors and aligning with GOMS principles.

2) Consistency-Through-Grammar: In the system design, Consistency-Through-Grammar (CTG) theories were applied to ensure clarity and user comprehension. Standardized language and logical sentence structure were used consistently across the interface, such as labeling allergens uniformly (e.g., "peanuts" instead of "groundnuts"). Clear text formatting, like using bold for allergen alerts, aided user understanding. These principles minimized cognitive load, enhancing usability and user satisfaction in allergen management software and similar applications.

3) User-Centered Design: User-Centered Design (UCD) principles was used to ensure the software effectively met the needs of our diverse user base. We began with comprehensive user research, which included surveys and usability tests to gain deep insights into users' goals and challenges related to allergen management. These insights informed the creation of detailed user personas, each representing different user types and their specific requirements. Throughout iterative design phases, we continually prototyped and tested the software with real users, incorporating their feedback to refine interface elements such as allergen labeling, alert systems, and navigation pathways. Emphasis was placed on usability and accessibility, with interfaces designed to be intuitive and easy to navigate, accommodating users with varying levels of technological proficiency. Consistency in design, including color coding for allergen alerts and standardized terminology, ensured a familiar and predictable user experience. Customizable settings for allergen management helped users to manage their interactions according to their preferences.

4) Object Action Interface: Object Action Interface (OAI) principles were utilized to enhance usability and clarity in managing allergens and alerts. The allergen drawer allowed users to input specific allergens, with actions like adding, editing, or deleting allergens directly associated with this interface. The toggle filter button controlled the visibility of allergen alerts, with the action of toggling alerts clearly linked to the button itself, providing immediate feedback. The alert dialog box appeared when users needed to confirm orders containing allergens, aligning the action of confirming or canceling orders directly with this dialog box.

VI. Testing and Results

A. Usability Testing

1) A/B Testing: During our A/B testing, we divided users into four groups of two people each. Two groups worked with Design A, while the other two groups worked with Design B. Design A achieved an average Task Success Rate of 70%, while Design B outperformed it with a 90% task success rate. This comparison highlighted Design B's superior performance in navigation, clarity of allergen information, and overall visual appeal, helping us identify which elements best met user needs and expectations.

2) Prototype Testing: Based on the in-person prototype testing, the low-fidelity prototype scored 72.4 on the SUS questionnaire, while the high-fidelity prototype scored 85.7. According to the interpretation of the SUS questionnaire, the low-fidelity prototype falls within grade B, with good acceptability, and the Net Promoter Score (NPS) classifies users as passive in their likelihood to recommend. In contrast, the high-fidelity prototype is classified as grade A+, with good acceptability and a higher likelihood of users recommending it, as indicated by the NPS. Thus, the SUS scores align with the high value of Task Success previously, indicating that the design prototype B is generally usable and effective.

3) Heuristic Evaluation: we conducted Heuristic evaluation to assess user interactions with the interface for managing allergens in online food delivery, using few of Jakob Nielsen's 10 Usability Heuristics [3]. The system's familiar terminology and intuitive navigation were well-received, with clear feedback enhancing user confidence (Visibility of System Status). Its clean, minimalist design made essential tasks easily accessible (Aesthetic and Minimalist Design), and consistent labeling clarified functionality (Consistency and Standards). However, insufficient error messages left users unsure about correcting issues (Help Users Recognize, Diagnose, and Recover from Errors). These insights guided iterative improvements to enhance the interface's intuitiveness and user-friendliness.

B. Pre-Survey Results

The pre-survey results reveal significant support for the inclusion of an allergy alert feature in food delivery apps, with 90% of respondents favoring it. Additionally, 60% of participants reported having personal experience with allergies, highlighting the relevance of such a feature. Remarkably, all respondents

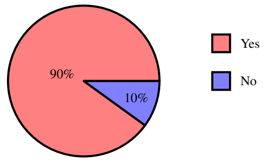

Fig. 3: Support for Allergy Alert Feature

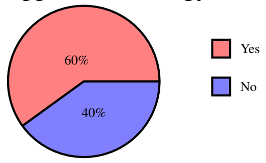

Fig. 4: Experience with Allergies

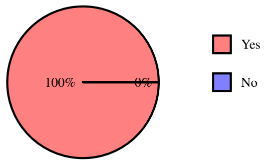

Fig. 5: Likelihood to Use App with Allergy Alert

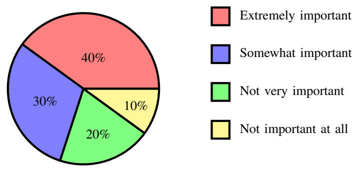

Fig. 6: Importance of Visible Allergy Disclaimer

(100%) indicated they would be more likely to use an app that includes an allergy alert system. Furthermore, the importance of having a visible allergy disclaimer was underscored, with 70% considering it either extremely important (40%) or somewhat important (30%), whereas only a small fraction deemed it not very important (20%) or not important at all (10%). These findings emphasize the critical need for enhanced allergy management features in food delivery services.

C. Post Survey Results

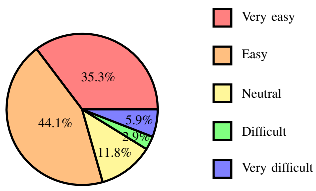

Fig. 7: Ease of Inputting Allergens

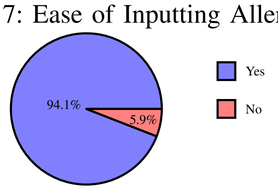

Fig. 8: Placement of Allergy Warning Description

The post-survey results for the food allergy alert system indicate a generally positive reception. A sig-

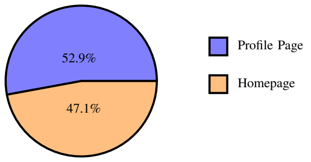

Fig. 9: Preferred Location for Allergy Filter Toggle

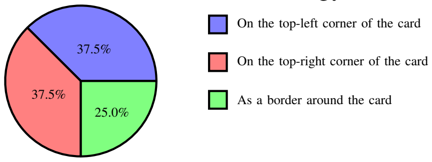

Fig. 10: Preferred Location for Warning Tag

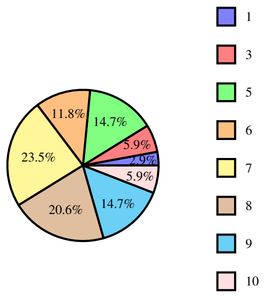

Fig. 11: Rating of Sensitivity Feature

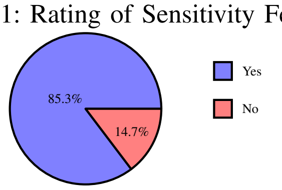

Fig. 12: Success of App in Highlighting Allergens

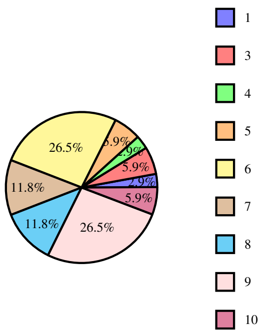

Fig. 13: Satisfaction with Allergic Constraints Feature

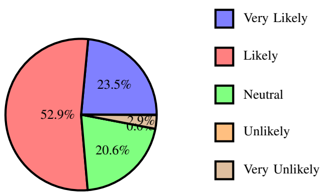

Fig. 14: Likelihood of Recommending the App

nificant majority found inputting allergens to be easy, with 35.3% rating it as very easy and 44.1% as easy. Nearly all respondents (94.1%) were satisfied with the placement of the allergy warning description. Preferences for the location of the allergy filter toggle were almost evenly split, with 52.9% favoring the profile page and 47.1% the homepage. The preferred location for the warning tag was equally divided between the top-left and top-right corners of the card (37.5% each), with 25.0% favoring a border around the card. The sensitivity feature received mixed ratings, with a peak at 7 (23.5%) and 8 (20.6%). Most participants (85.3%) felt the app successfully highlighted allergens. Satisfaction with the allergic constraints feature varied, with 26.5% rating it 6 or 9, and lower ratings dispersed among other options. Lastly, the likelihood of recommending the app was high, with 76.4% indicating they were very likely or likely to recommend it, while a small percentage (2.9%) were very unlikely to do so.

VII. Discussion

The Food Allergy Alert System was developed to enhance user safety in food delivery applications by identifying and alerting users about potential allergens. Utilizing a comprehensive allergen database and personalized allergy profiles, the system provided real-time alerts. The research employed a user-centered design approach, integrating extensive user feedback gathered through pre-surveys, prototype testing, and post-surveys. The findings indicated strong support for the allergy alert feature, with 100% of respondents favoring its inclusion and all respondents indicating an increased likelihood of using the app. Usability testing revealed that users generally found the system easy to navigate and effective in highlighting allergens. Design refinements, including adjustments to the placement of the allergy filter toggle and warning tags, were made based on user preferences. Overall, the study suggests that integrating a food allergy alert system into food delivery applications has the potential to enhance user safety and satisfaction significantly.

VIII. Conclusion and Future Work

The development and testing of the Food Allergy Alert System show great potential to improve safety and user experience for individuals with food allergies using food delivery apps. Through a user-centered design approach, the system effectively addresses real-time allergen identification, with positive user feedback and high satisfaction. A/B testing demonstrated that Design B, with a 90% task success rate, outperformed Design A's 70%, highlighting better navigation, clearer allergen information, and greater visual appeal. In-person prototype testing further supported these findings, with the low-fidelity prototype scoring 72.4 on the SUS questionnaire (grade B), while the high-fidelity prototype scored 85.7 (grade A+). The alignment between high SUS scores and task success rates confirms Design B's usability and effectiveness.

Since the online pre- and post-surveys were uncontrolled (i.e., were not submitted by same group of people), the SUS scores from those surveys were excluded due to potential biasness. However, we plan to implement controlled online surveys in future studies to estimate accurate SUS scores. Further research with larger, more diverse populations is recommended to validate these findings and further enhance the system's overall effectiveness.

IX. Acknowledgments

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