Food Allergy Alert System: A User-Centered Design

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***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 employed, including surveys, prototype testing, and user feedback sessions. Participants from diverse backgrounds were involved to ensure comprehensive insights.
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 revealed high user satisfaction with the system's features. Pre-survey results showed strong support for allergy alert features, while post-survey feedback indicated positive reception of the implemented system.
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 [9]. 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 [5]. 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 [4]. 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. [6].

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 [8]. 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 [7].

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 [7].

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 [7].

E. Evaluating Interface Design

Evaluating interface design involves a comprehensive process to ensure the interface is user-friendly, intuitive, and effective in meeting user needs. Ben Shneiderman in "Designing the User Interface" describes several key approaches for this evaluation. Heuristic evaluation has experts review the interface against established usability principles, such as visibility of system status, error prevention, and aesthetic design, to identify potential usability issues. User testing involves observing real users as they interact with the interface, gathering data on task completion rates, error rates, and user satisfaction. Cognitive walkthroughs allow evaluators to simulate new user interactions to identify cognitive mismatches and potential difficulties. A/B testing compares two versions of an interface to determine which performs better in terms of user engagement and task success. Additionally, analyzing user interaction data through metrics and analytics helps uncover patterns, common errors, and points of user abandonment [7].

IV. Methodology

A. Participants

Participants in this research study were incorporated from an age group below 55, coming from various walks of life and professions, making it an open survey. We classified some information based on the responses, which allowed us to gather constructive feedback and suggestions related to a few features of the system from expert users. Knowing what features to remove and what to add was very helpful in making the process more user-friendly and interactive. Our goal was to include all types of users, whether novice, knowledgeable, or expert, to participate in the survey to get their insights on their experience with any allergens and the troubles faced due to them during online food delivery. Similarly, for the prototype session, we involved friends, colleagues, and families, reviewing the prototype with a few experts in the field. This approach provided valuable constructive suggestions, which we 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.

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. 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.

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 warning tags and color coding across all food item

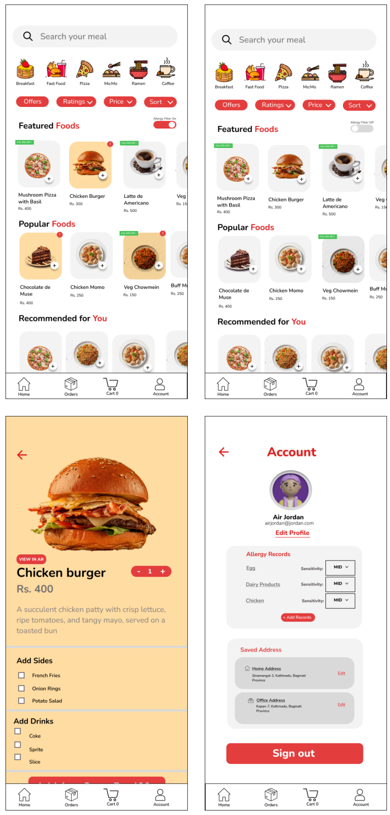

Fig. 1: Prototype Demo Images I

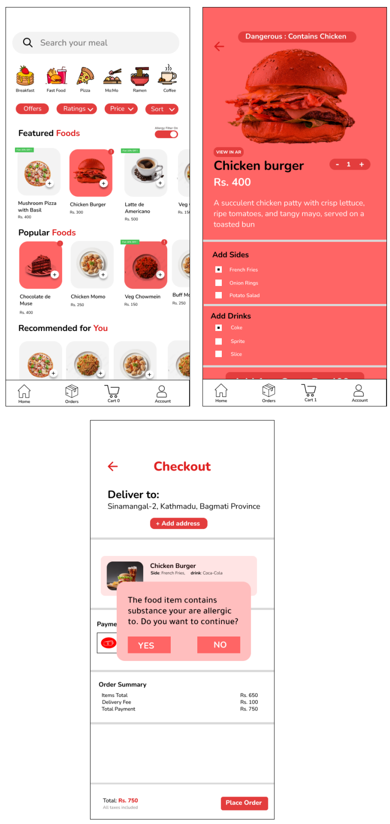

Fig. 2: Prototype Demo Images II

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 evaluated two design variants of the system, focusing on both its functionality and aesthetic features. This involved participatory sessions where users actively engaged with both versions, providing real-time feedback on their experiences. Additionally, we conducted persona-based sessions to gather detailed insights into how different user groups interacted with the designs. The A/B testing revealed preferences in navigation, clarity of allergen information, and overall visual appeal. By comparing user responses, we identified which design elements effectively met user needs and expectations, guiding us toward the most user-friendly and visually appealing solution.

2) Prototype Testing: We conducted Prototype testing in followed a systematic approach, beginning with a pre-testing phase where initial prototypes were developed to simulate features such as allergen input, toggle filter button, warning tags, allergen sensitivity settings, warning texts, and confirmation dialog boxes. During pre-testing, users participated in controlled sessions to provide feedback on usability issues and interface clarity. Insights gathered from these sessions guided iterative refinements to the prototype design, focusing on improving user interactions and addressing challenges such as complex allergen input methods or unclear interface elements. In the subsequent post-testing phase, revised prototypes incorporating these refinements were evaluated by users to validate improvements based on earlier feedback. This iterative process of refinement and validation continued until usability concerns were effectively addressed.

3) Observational Testing: We conducted Observational testing to observe and analyze how users interacted with the interface while managing allergens in online food delivery. We conducted real-time observations of users as they navigated through the system and performed tasks such as inputting allergens, adjusting sensitivity settings, and interpreting warning tags. This method focused on capturing user behaviors, reactions, and challenges faced during interaction. Observational sessions provided qualitative insights into usability issues such as navigation difficulties, confusion with interface elements, and the effectiveness of allergen management features. These insights guided iterative improvements to enhance the interface and overall user experience, ensuring it met user needs effectively.

4) 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 (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

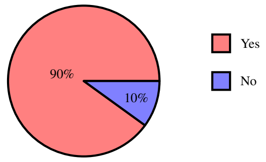

Fig. 3: Support for Allergy Alert Feature

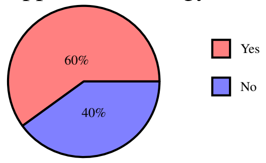

Fig. 4: Experience with Allergies

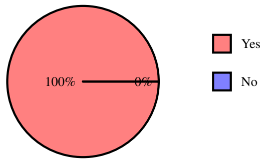

Fig. 5: Likelihood to Use App with Allergy Alert

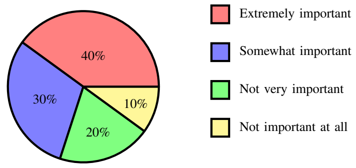

Fig. 6: Importance of Visible Allergy Disclaimer

(10%). These findings emphasize the critical need for enhanced allergy management features in food delivery services.

C. Post Survey Results

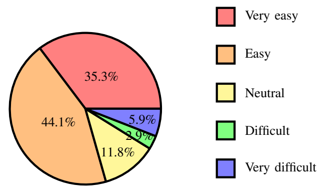

Fig. 7: Ease of Inputting Allergens

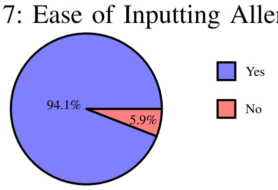

Fig. 8: Placement of Allergy Warning Description

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

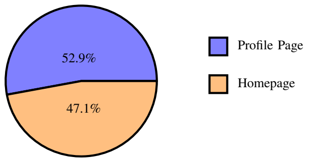

Fig. 9: Preferred Location for Allergy Filter Toggle

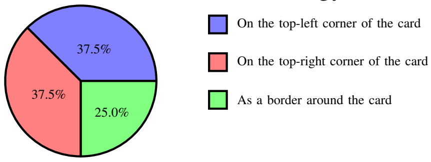

Fig. 10: Preferred Location for Warning Tag

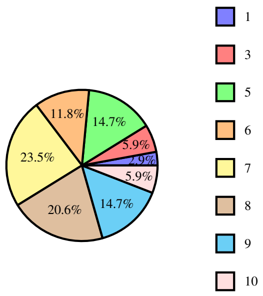

Fig. 11: Rating of Sensitivity Feature

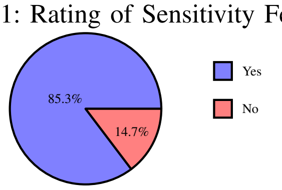

Fig. 12: Success of App in Highlighting Allergens

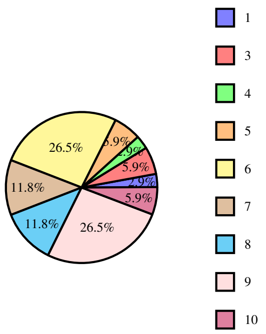

Fig. 13: Satisfaction with Allergic Constraints Feature

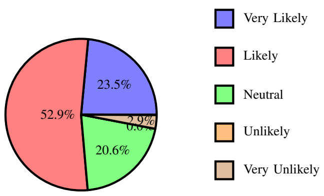

Fig. 14: Likelihood of Recommending the App

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

The development and testing of the Food Allergy Alert System highlight its potential to significantly improve the safety and user experience of food delivery applications for individuals with food allergies. By employing a user-centered design approach, the system effectively addresses the need for real-time allergen identification and alerts, as evidenced by positive user feedback and high levels of satisfaction. The iterative design process ensured the system was user-friendly and met the diverse needs of its users. While initial results are promising, further research with larger, more diverse populations and direct interaction with the system is recommended to validate these findings and enhance the system's effectiveness.

IX. Acknowledgments

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