Mobile Application for Celiac Disease Patients' Wellness and Support

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Abstract. Celiac disease affects an estimated 1% of the population. The only existing treatment is a strict gluten-free diet but there are myriad aspects of managing the disease that affect the lifestyle of both the CD patient and those close to them. The goal of this study was to design, develop and test a prototype of a mobile application to promote wellness and support for individuals with CD. The proposed application's aim is to serve as a platform for CD patients and members from their social circle, to help with sharing general and specific information about four lifestyle aspects: social, emotional, food, and wellness. The application aids with the management of a gluten-free diet from the social circle perspective for the specific CD patient. Perceptions towards the usability of the application were gathered from 22 participants and analyzed via a USE questionnaire. The results from the survey reported overall satisfaction of the prototype and useful insights were gathered for subsequent versions. The general expected benefit of this evidence-based application is improved quality of life for the CD patient due to their social circle being well informed about the management of the disease and its potential complications.

Keywords: Mobile application · mHealth · Celiac disease · Medical informatics · Gluten-Free

1 Introduction

Autoimmune diseases (AID) include a wide variety of illnesses targeting different parts of the human body. The American Autoimmune Related Disease Association (AARDA) has classified more than 100 AID, making it the third most common type of disease in the United States. The AARDA identifies AID as a major health problem affecting up to 50 million individuals in the United States alone, which translates to an alarming 15% of the population. Some AID are within the top 10 leading causes of death among women aged 65 and older, and 75% of Americans with AID are women. According to the AARDA website, AID are responsible for more than 100 billion US dollars annually in direct healthcare costs and most AID patients see four doctors over three years before a correct diagnosis [8].

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Many autoimmune diseases seem to vary in incidence by region or ethnicity. For instance, Southern European and Asian countries have a lower incidence of type 1 diabetes and multiple sclerosis than do Northern European countries. This variation may be caused by the irregular prevalence in specific ethnic groups of a gene associated to a particular AID. Likewise, dissimilarities in diet or in the existence of a triggering pathogen or chemical agent due to geographic factors may affect the frequency of an AID [22]. Regardless of the public health scale of the problem, the unknown aetiology of AID, the complexities involved in diagnostics, the increased costs, and the unavailability of cures, scientific research has focused on a small portion of more than 100 known AID [12].

Celiac Disease (CD) is an AID that requires effective self-management in adherence to a strict gluten-free diet (GFD), which is the only existing treatment for the disease. The list of symptoms that CD patients have is extensive and varies from childhood to adulthood. Some of the symptoms that are commonly experienced by children are abdominal pain and stunted growth issues. Moreover, symptoms that adults can experience are diarrhea, fatigue, anemia and reduced bone disease, among many others [27]. The proportion of people with CD varies among regions in the world. The reported prevalence of CD in South and North America was 0.4%–0.5% whereas the value for Asia was 0.6%. However, the prevalence in Europe and Oceania was slightly higher at 0.8%.

One of the authors of this study has CD and understands the importance of technological support for the management of the condition. As with any chronic disease, support is a team effort in conjunction with the social circle of the patient. With CD, the patients find themselves having to explain their condition numerous times, and providing the same CD information repeatedly. Therefore, a one-stop platform that centralizes accurate and readily-available information, personalized to each CD patient and their social circle, is of utmost importance. With feedback from other CD patients and analysis of well-reputed CD websites, we designed and developed a prototype of a mobile application to promote wellness and support for patients suffering from CD. A total of 22 CD patients and members from their social circle tested the initial prototype of the mHealth application and responded to a survey after the trial. The survey acquired perceptions towards the features of the app and usability of the design. The prototype contains general CD information due to the broad spectrum of CD symptoms. However, in future versions, the app will include information personalized to each patient. The patients will, therefore, be able to share individual pre-approved food and restaurants with their social circle, along with preferences and information about the disease and other psychological disturbances that accompany the disease, for each specific case.

The remaining sections of the study are as follows: Sect. 2 entails information about CD and how social support can aid the patient managing the disease thus explaining the problem statement and the need for the mHealth app. Related mobile applications for gluten intolerant people and CD patients are described in Sect. 3. In Sect. 4, the design of the application is visualized and explained in detail. The results from the survey are reported and analyzed in Sect. 5. Finally, Sect. 6 details the findings along with potential benefits, limitations of this study, and future work.

2 Problem Statement

In countries like the United States, the United Kingdom, and Germany, approximately 20% of the population has been reported to experience adverse reactions to foods such as wheat, nuts, fruits, and milk [13]. Historically, wheat-related disorders have been identified as CD and wheat allergy or non-celiac gluten sensitivity [23], referred as gluten intolerance in this study. Gluten-related conditions vary significantly in aetiology, but adherence to the GFD is of utmost importance for CD patients due to gluten reactivity involving autoimmune mechanisms [28].

Celiac disease is a systemic autoimmune disorder activated by gluten in genetically-predisposed individuals and affects an estimated 0.5 to 1.0% of the population worldwide [19]. Gluten is a protein found in cereals such as wheat, rye, and barley. CD is characterized by an extensive range of symptoms, a specific serum auto-antibody response, and variable damage to the small intestinal tract. Diagnosing CD can be difficult because some of the symptoms overlap with myriad other diseases, such as irritable bowel syndrome, chronic fatigue syndrome and depression. Since CD is hereditary, it is recommended that family members get tested as well. The longer the individual remains undiagnosed and untreated, the greater the chances of developing complications [15].

The treatment for CD is a lifelong GFD. However, some people do not improve on this diet and face additional health complications due to their deteriorating health. The adherence to this strict dietary regime varies among patients and is the main cause of persistent symptoms [15,18]. Therefore, it is advised to develop effective strategies to help patients follow a strict GFD, manage their various symptoms, and deal with all the implications of CD [16]. Participation of a close support group for the CD patient has been associated with higher quality of life scores, especially when face-to-face interaction may improve long-term quality of life and health outcomes [25]. Therefore, we recognize the need for a mobile application that helps CD patients manage their specific condition with support from their immediate social circle. We leave aside the search functionality through a catalog of gluten-free (GF) foods, because the majority of mobile health (mHealth) applications on the market today for CD patients are focused on finding GF food.

Following a strict GFD has a significant negative impact on quality of life in social settings for CD patients. Particularly related to social aspects such as traveling, eating out, and family life. Lee et al. [24] reported that CD patients, even though they know it will cause damage, typically cheat on their GFD because: 46.3% think the diet limits their social life, 55.3% perceive the diet as embarrassing, 24.9% say dining out is too difficult, 30.8% say the diet is socially isolating, and 33.3% report family and friends do not understand the need to follow the diet. Social support is therefore crucial for adherence to the GFD. Some solutions suggested by Lee et al. [24] are accommodation by family and friends, school and community support, group support, and others in their circle following a GFD.

3 Literature Review

The identified related work are mHealth applications that allow patients to self-regulate their health and diet in real time. Most applications aid in understanding the nutritional content of food consumed and focus on regulating lifestyle choices and diet. Within those applications, there are additional functionalities for identifying GF food for gluten intolerant individuals or CD patients [17,21,29]. However, there are CD specialized applications available on the market which contain more functionalities to monitor symptoms and the disease itself, such as *MyHealthyGut* [16] and *Eat! Gluten-Free* [2]. Additionally, a mobile tool for automated text messaging was identified in the literature, it aims at improving CD patient engagement and ultimately the quality of life [20].

3.1 mHealth Applications for Gluten-Free Diet

The Gluten-Free Living Association recommends several user-friendly mHealth applications which aid gluten intolerant individuals adhering to a GFD. Whether it is to find a GF product or restaurant or even if the GF requirements need to be communicated in a different language, these applications are a mean to assist in daily life [29]. Nonetheless, extra precautions need to be taken by the CD patient to ensure the foods are not only GF but also safe for individuals with CD due to cross-contamination in the kitchen. The vast majority of the reported mHealth applications in the section can be found in the list of recommendations from the association. Additionally, identified scientific literature is provided for two of the applications. In Table 1, the identified mHealth applications for gluten intolerance and CD are listed along with a short description of each application.

The *Find Me Gluten Free* application is for individuals that have gluten intolerance of any kind and patients with CD. The application contains information and reviews from members of the GF community of approved restaurants, grocery stores and cafes [3]. *AllergyEats* is a similar application that locates allergy-friendly restaurants in the United States and users can read reviews about the recommended restaurants and make their decisions accordingly [1].

The barcode-scanning technology is common in mHealth applications for understanding in a quick and easy way whether the product contains gluten and other nutritional values that are of interest for patients with CD and other gluten sensitivities. Applications that operate with this technology and recommended by Gluten-Free Living association are *The Gluten Free Scanner* [7], *Sift Food Labels* [11], *ShopWell Diet* [10] and *Is that Gluten Free?* [5].

Dunford et al. [17] describe the *FoodSwitch* application that uses barcode-scanning technology. The app operates with a large database of branded food which includes information on energy, protein, sugar and fiber. It provides users with nutritional information of packaged food in an easy language and suggests healthier alternative products if applicable. The initial launch of the application proved to be highly successful and in response to that the GlutenSwitch functionality was implemented later on. With the added functionality, people could

receive recommendations and information on GF food, targeted mainly to CD patients and gluten intolerant individuals [17].

Handel [21] reviewed several mHealth applications of good quality that provide "information, strategies, and tracking capabilities related to patient self-management, health and wellness approaches". The mHealth application *Is That Gluten Free?* was one of these good quality applications that was discussed in the article [21] and recommended by the Gluten-Free Living Association as mentioned earlier [29]. The selection was based on several quality criteria such as ease of use, scope of information, recommendations and professional expertise. *Is That Gluten Free?* is an application that includes a large amount of verified GF products targeted for CD patients and other gluten intolerant individuals. The database includes comments from the manufacturers of the GF products and information regarding cross-contamination [21].

Education in mHealth applications is also of importance for individuals struggling with food intolerance, allergies, digestive-related problems, and CD. The main purpose of the *mySymptoms Food Diary* application is to educate about various diseases and discover patterns that relate consumption of food and symptoms. The users can not only track the food but also medication, exercise and emotions. Additionally, the application has a multi-user platform, meaning that every family member or other members in the social circle can have their own personalized page and share between one another [9].

3.2 mHealth Applications Specialized for Celiac Disease

The Celiac Disease Foundation is a leading disease advocacy group for CD in the United States. The foundation introduced an mHealth application in 2015, *Eat! Gluten-Free*, specialized for CD patients. The application contains a large digital hub of GF products along with pictures, recipes and details about the manufacturers. Additionally, CD patients are provided with the latest news and research concerning their disease [2].

Dowd et al. [16] developed a theory-based mHealth application, *MyHealthyGut*, for individuals to effectively deal with CD through self-management and subsequently improve their gut health. Perception and desired functions were gathered from CD patients and healthcare professionals through questionnaires and focus groups. Ninety percent of the participants reported a need for an app to help them manage celiac disease and that the most determining factors for using the app were "ease of use, available functions, nutritious GF recipes and cost". Additionally, participants considered the functionalities tracking the GFD and symptoms, supplements for healthier gut and cooking instructions, to be valuable for managing the disease and increase their quality of life.

Table 1. Available mHealth applications for gluten intolerance and CD patients.

Category	Name of application	Description	Price	Source
Dining out	Find Me Gluten Free	Locates GF restaurants, bars, grocery stores, cafes, etc. Users can additionally find information about the menus and contact information	Free	[3]
	AllergyEats	Users can find allergy-friendly restaurants in the US and search based on their personal food restrictions	Free	[1]
	Gluten-Free Restaurant Cards	The application contains 40 card images from CeliacTravel.com. Those cards can be shown to the staff of the restaurants and can be found in many languages	Free	[6]
Grocery Shopping	Fooducate Healthy Weight Loss & Calorie Counter	With the use of Barcode scanning technology, the user can find easily accessible nutritional information about products in the grocery store	Free, (gluten functionality needs to be purchased)	[4]
	The Gluten Free Scanner	Users can scan in products and each product that is scanned gets graded based on its nutritional value	$3.99	[7]
	Is that Gluten Free?	Large database of verified GF products and information about the manufacturers	$7.99	[5]
	Sift Food Labels	Barcode scanning technology and user-given easy, broken down information about the nutritional value	Free	[11]
	ShopWell Diet, Allergy Scanner	Barcode scanner with large, database. Additionally, to gluten the app provides allergy alert for example peanuts and soy	Free	[10]
	FoodSwitch	Bar-scanning technology and the GlutenSwitch functionality can be found within the application that is specifically for the GFD	Free	[17]
Gluten-Free Education	mySymptoms Food Diary	Track food that is consumed, symptoms and bowel movements for CD patients and food intolerance patients	Free	[9]

3.3 Automated Text Messaging Tool for CD Patients

The effectiveness of *Text Message Intervention (TEACH)* as a pragmatic approach for engaging CD patients was studied among adolescents in a randomized trial. The purpose of the tool was to aid younger patients suffering from CD due to the fact that they are more likely to not follow the strict GFD compared to other groups. The tool sends automated text messages and its intention is to educate and increase the engagement among young adults. The reported results from the study indicated a significant improvement in patient activation and quality of life for the adolescents in the TEACH intervention group [20].

3.4 Deficiencies of mHealth Applications

Some deficiencies were identified among mHealth applications for CD disease and gluten intolerance. The focus of the proposed mHealth application of this study is CD *patients* whereas the vast majority of the applications focus on gluten intolerance and CD. As was reported by Sapone et al. [28] the two conditions vary greatly, where CD is the "only clinical form of gluten reactivity involving autoimmune mechanisms." The adherence to a strict GFD is therefore ever more important for the CD patient. The *mySymptoms Food Diary* is the only identified application that provides multi-user functionality [29], which demonstrates the need for an mHealth application where CD patients can share lists of GF food and restaurants they trust and other important information about CD with their social circle. This can improve their overall quality of life and adherence to the GFD [24]. Lastly, psychological disturbances, such as anxiety and depression, have been associated with CD [14]. None of the identified mHealth applications address mental health of CD patients. The proposed application of this study includes information and common symptoms of mental health illnesses that CD patients might experience after being diagnosed with the disease, the goal with subsequent prototypes is to customize this information for the specific CD patient using the app.

4 Methods

The goal of the app is to serve as a platform for interaction between the CD patient and their social circle, namely the target users of the application. The app is to be used as a centralized place to exchange relevant information and gain understanding needed for social interactions, but more importantly, to give the patient a sense of safety and belonging. As reported by Lee et al. [24], social support is crucial for the CD patient in terms of accommodations by family and friends. That support can ultimately improve the patient's quality of life [25].

4.1 Design of the Prototype

The prototype was designed, built and deployed with the JustInMind[1] toolkit. This is a free, all-in-one prototyping tool for web and mobile apps. The toolkit provides a comprehensive library of UI components, objects and controls for Android and iOS mobile prototypes. With this tool, the developer can build a simple wireframe and interactive prototypes.

The initial prototype consists of 21 screens divided into four main sections: *Social, Wellness, Food* and *Emotional*. See Fig. 1 for the thank you screen for testing the prototype, the main menu of the app and the main screens of the aforementioned four sections. A sample screen from each of the four sections of the app can be seen in Fig. 2.

[1] https://www.justinmind.com/.

To design these four sections, we interviewed a CD patient, gathered feedback through the *celiac.com* website, and did an analysis of the sections included in well-reputed websites such as *beyondceliac.org*, *gluten.org*, and *celiac.org*. The CD patient expressed that they would like an app that has information about "our symptoms, a food section and traveling tips!" On the *celiac.com* forum, we received insights on having a food list such as:

> "Many of us have various food intolerance issues and have a whole list of foods we can not have, because I hate having to practically repeat my list to the family. Like a catalog. So family knows which prepackaged products we like and they can bring. Family traditions often involve bringing something over food wise. If they have the ability to know what they can bring, I think it could offer a way to deepen interactions and get the family involved."

Lastly, from the three main well-reputed websites mentioned above, we were able to identify the most common topics they cover (other than finding GF foods, which is not the focus of the app), which are: symptoms, testing and diagnosis, living with CD, community, concerns, GFD, recipes, food safety (cross-contamination), diet and nutrition, health and wellness, lifestyle, restaurants, children with CD, living GF, meals, dining GF, and social eating. We incorporated most of these topics in our first prototype. Keeping in mind that the main goal of the app is social circle support, it is important to acknowledge that the target group are CD patients alongside their social circle.

The Four Sections of the Prototype. The first section of the app is the *Social* section. It contains four subsections: *Celiac 101, Socializing, Dating*, and *Traveling*. The *Celiac 101* section is designed to provide a snapshot of CD by supplying statistics about the condition. Moreover, this subsection explains that CD is a chronic, genetic disorder that affects the CD patient's lifestyle. The second subsection, *Socializing*, explains the dynamics of dining out and gives a list of questions to ask when eating at restaurants; it also gives advice on what to do, such as always carrying snacks. The third subsection, *Dating*, covers dating by giving tips and ideas for sharing information with potential and current partners, such as which questions to ask, communicating, and planning ahead. The last subsection, *Traveling*, gives traveling tips and advice since finding GF options can be difficult in a foreign country with a foreign language.

The next section of the app, *Food*, covers dietary aspects, by means of four subsections: *Restaurants, Grocery List, What To Watch For* (cross-contamination), and *Quick Guide*. The *Restaurants* subsection has a list of restaurants approved by the CD patient, because of experience or preference, making it easy and stress-free to decide where to eat when dining out, with a Google Maps component. The *Grocery List* is similar to the restaurant list because it features a customized grocery list that helps both the CD patient when shopping for groceries, as well as friends and family when trying to decide which groceries to buy for a social gathering. The third subsection, *What to Watch For*, features a list of common sources of cross-contamination, which can

Fig. 1. Thank you screen, main menu and four sections of the mobile app: Social, Wellness, Food, Emotional

be very hard to manage because there are many sources and ways in which food and environment can become contaminated with gluten and make the CD patient ill. The last subsection offers a *Quick Guide* to easily distinguish GF foods from unsafe foods, answering the question: "What *can* you eat?"

Fig. 2. Sample screens from each of the main sections of the app

General information about how good sleeping habits are maintained, increasing well-being with practices such as meditation, the varied symptoms of CD and the benefits of exercise are provided in the *Wellness* section of the application, by means of the following four subsections: *Meditation, Symptoms, Sleep*, and *Exercise*. In Fig. 2, the list of possible CD symptoms are shown as designed in the prototype.

Lastly, the *Emotional* support section brings up the importance of being aware of how mental health can be affected once diagnosed with CD. Symptoms (that the patient should pay close attention to) are listed, such as "crying a lot for no particular reason" and "feeling worthless or extremely guilty", in the *Mental Health* subsection. Special attention is put towards education on general anxiety in the subsection *Anxiety* in the application, due to the numerous CD patients who experience symptoms of anxiety disorder after being diagnosed. Fast facts are given in the subsection *What You Should Know*, see Fig. 2, such as *it is hereditary* and *it robs you of spontaneity of traveling freely*. The *Impact* subsection contains information about how CD can impact the CD patient. For example, an alarming 80% of CD patients believe CD is a burden in their lives or that women with CD are significantly more likely to miscarry or give birth prematurely than other women.

4.2 Method

By means of a survey, the perception of usability of the prototype was gathered from the app target: CD patients and their family and friends, along with which functionalities they would modify or include in future versions of the mobile app. There were two types of participants: informed CD patients and informed social circle. The participants were notified that they could withdraw from the survey at any time and remain anonymous. The survey was adapted from the USE Questionnaire [26] and measured participants' usability perception towards four categories: *Usefulness, Ease of use, Ease of Learning* and *Satisfaction*, on a five point Likert scale. Additionally, the survey acquired information about overall satisfaction of the four main sections of the app, open-ended questions about the sections and subsections, as well as additional comments.

5 Results

In order to analyze the results from the USE Questionnaire, averages were calculated for the scores per the following categories: *Usefulness, Ease of Use, Ease of Learning* and *Satisfaction*. The results were then scaled to 100% from a five point Likert scale, ranging from Strongly Disagree to Strongly Agree. The overall response rate was 100% due to all questions being marked as *required*, with the exception of the two open-ended questions for which eight and seven answers were received respectively. A total of 22 people participated in the testing of the prototype and answering the survey. The results per category were as follows:

Usefulness. The overall perception of the *Usefulness* of the application was positive amongst the participants, ranging from 3.73 to 4.73 in the five point Likert scale, see Fig. 3. The lowest score (3.73) was reported in "The app does everything I expected it to do", this is well reflected in the various suggestions provided by the participants for more functionalities that ought to be included in future versions of the application, such as "recipes" and "restaurant cards".

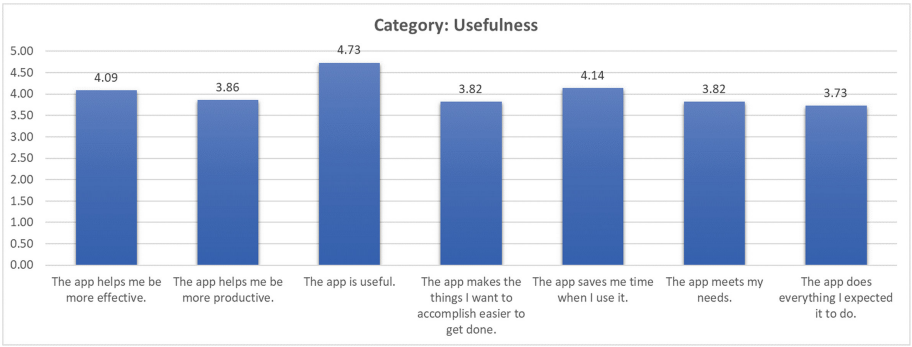

Fig. 3. Category Usefulness results

Ease of Use. In the category *Ease of Use*, the participants found the application easy to understand and manipulate. However, the majority of the participants reported the flexibility and recovering from mistakes in the application as "Neutral". See Fig. 4 for the reported numbers for each question in the category.

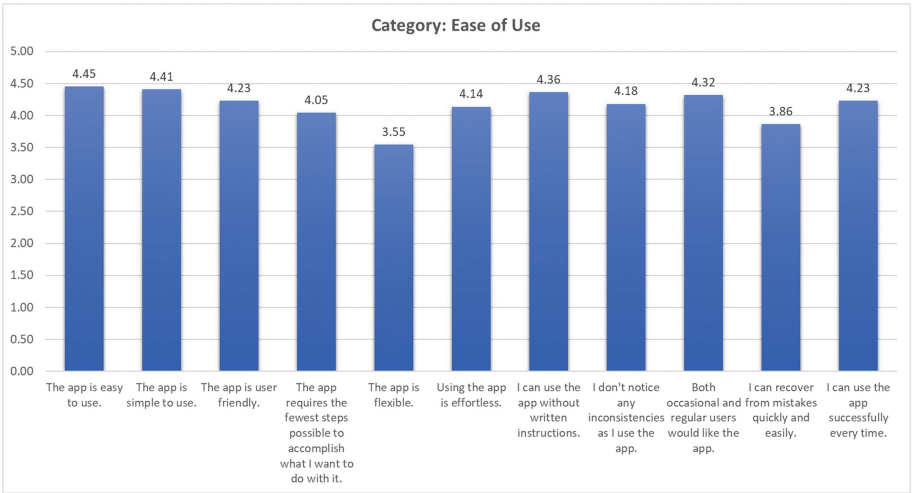

Fig. 4. Category Ease of Use results

Ease of Learning. The reported ability to learn ranged from 4.23 to 4.55 in terms of how quickly and easily the participants learned to use the application, see Fig. 5.

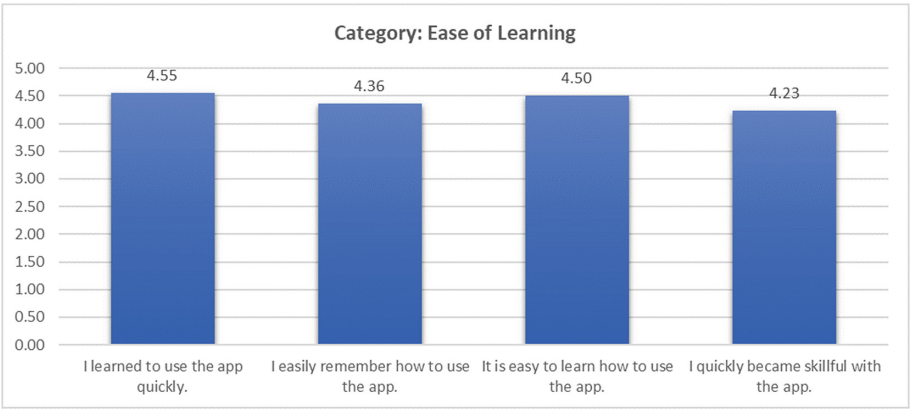

Fig. 5. Category Ease of Learning results

Satisfaction. The participants reported overall *satisfaction* of the design, ranging from 3.68 to 4.55 in various subcategories, see Fig. 6 for all reported values. The participants indicated that they "felt they would need the app" and they "would recommend it to a friend", where both subcategories were reported as 4.55 (Agree).

The results from the four categories of the USE questionnaire report overall positive perceptions towards the usability of the application, indicating that CD patients are willing to share with their social circle the general information about the disease and thereby decreasing the social anxiety that comes with the feeling of exclusion. Additionally, the social circle is willing to actively participate in the

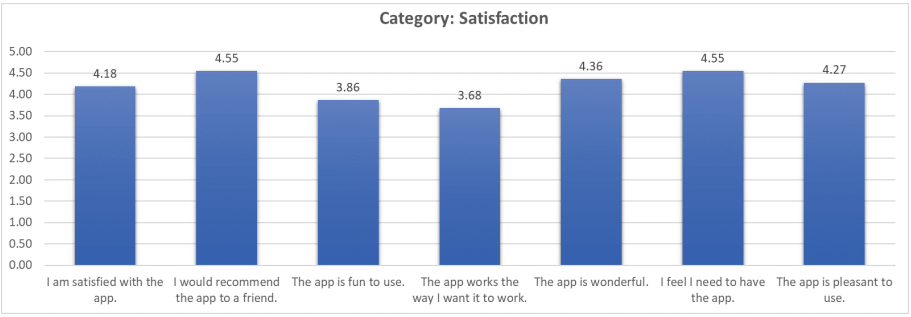

Fig. 6. Category Satisfaction results

management of wellness and support for CD patients, recognizing the important role their involvement plays in a CD patient's improved quality of life.

The average result per category can be seen in Table 2. The reported values for the four categories were somewhat similar, from 4.02 to 4.41. The *Satisfaction* category reported the highest perception (4.41) amongst the participants, however, the regard to the *usefulness* of the design was reported the lowest (4.02) of the four.

Additionally, questions on overall satisfaction rating of the four app sections were gathered and the reported median for the all the categories were 4, see Table 3. It is important to mention that the *Wellness* section had four out of 22 responses marked as 2 on the five point Likert scale, meaning that they were *dissatisfied* with this section.

Table 2. Summary of results per category from USE Questionnaire using Likert scale

Category	Average score	Scaled to 100	Likert scale
Usefulness	4.02	80.33	Agree
Ease of Learning	4.16	83.18	Agree
Satisfaction	4.41	88.18	Agree
Ease of Use	4.21	84.16	Agree

From analyzing the answers to the open-ended questions that were included in the survey, categories were identified via clustering by affinity of topic, Fig. 7 presents a word cloud summarizing the findings. The open-ended questions were optional, thus we consider respondents of these questions as "key users" or users that demonstrated an increased interest in development of the app. From the suggestions by the key users, the following were determined as the most important benefits they expect from the app: appealing user interface, gluten-free restaurants list, lower stress from explaining the GFD, family stories/testimonials, buying GF items, help with different languages, GF recipes, medical information, fast performance, and interactive/customizable design.

Table 3. Median scores of overall satisfaction of four app sections - results from USE Questionnaire

App section	Median score	Likert scale
Social	4	Agree
Wellness	4	Agree
Food	4	Agree
Emotional	4	Agree

Regarding the user interface, respondents said: "nice construction", "fantastic", "very cool", "great design"; one respondent pointed out that the text was

"small". Regarding GF shopping, one respondent made the following statement, "I would add a section of other items that contain gluten, such as makeup, toiletries, etc. I would also add a recipe section, as I find it's one of the most challenging aspects of being celiac: what to eat on a daily basis." Lastly, another respondent added, "This would help with going on vacation, without having stress to find an explanation anywhere on the internet."

Fig. 7. Word cloud summarizing the findings from open-ended questions.

6 Discussion

6.1 Findings

The majority of the respondents perceived the usability of the application as useful, easy to learn, satisfying and easy to use. The reported average scores in the previously mentioned categories ranged from 4.02 to 4.41 (Agree), on a five point Likert scale, see Table 2, Which indicates a positive attitude of the interaction of the app and its' potential for future releases. Additionally, participants were satisfied with the four sections of the application: *Social, Wellness, Food* and *Emotional*, where the reported median scores were 4 (Agree) for all categories, see Table 3. The overall perception of the application was well-conceived where participants reported the design as appealing and user friendly.

Like Handel [21], who based the selection of quality mHealth applications on several criteria such as ease of use and aesthetically pleasing applications, the reported findings also indicate that the proposed application can be considered of high quality due to high scores of the perceived usability.

Finally, some suggestions for future development of the applications were provided from the respondents such as diversity of languages, a recipe section, a testimonials section, and a list of non-food items containing gluten.

6.2 Potential Benefits

The potential benefits of the proposed application for CD patients, which in turn could improve the patients quality of life, are:

- Potentially decreasing limitations in personal and social life, such as traveling and participating in celebrations.
- Possibly providing better GFD support and knowledge from social circle, such as having GF and celiac-safe options for CD patients at all social gatherings.
- Likely decreasing anxiety related to the fear of falling ill from food consumption and inconvenience of finding GF options when dining out.
- Enabling the GFD to be less socially isolating and more inclusive by providing appropriate and accessible information easily and quickly to the social circle.
- Supplying enhanced understanding of the overall impact of the condition from family and friends, not just in terms of physical health but also mental health and lifestyle choices.

6.3 Limitations

Failing to find enough suitable subjects willing to test the app prototype is a limitation in this study. Therefore, the sample size was small. There were two types of participants for the survey: 1) informed CD patients and 2) informed social circle. The target group for participating in the study were CD patients who are aware of their symptoms and have experience managing their condition through lifestyle changes and following a strict GFD. The social circle of these particular CD patients has to be willing to be helpful and understand how important social support and overall wellness is for the CD patient. If they are not aware of this factor, then the mobile application will not seem useful to them. The latter can be an important limitation to this study because these type of subjects are difficult to find in large numbers. Creating enough incentives for users to frequently use the app could be another limitation, but more testing needs to be performed to determine user loyalty.

6.4 Future Work

Scientific publications on mHealth applications for CD patients are scarce and only one study was identified in the literature that described an application for managing CD exclusively [16]. Consequently, there are multiple opportunities to perform research on the topic. Potential future work and future versions of the prototype include expanding the range of target users of the application. The application has great potential of helping other patients with food intolerance issues and who are interested in managing their diet for medical reasons

because sharing it with their social circle would positively impact their quality of life. Additionally, the application can be modified for adhering to the needs of children in future versions. Finally, valuable data was gathered from the survey, where the participants provided suggestions for potential features for future versions of the application. Remarks mentioning a more interactive design and personalization are paramount because these are core benefits the app will offer in the final version and a competitive advantage, contrasting with other mHealth apps. Additionally, further prototypes could be adapted and used for other long-term conditions that require similar strict diet management such as food intolerance and allergies, i.e. fish, peanuts, tree nuts, milk, eggs, shellfish, wheat, soybeans, etc.

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