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LiverCare Registry: Designing an mHealth App for Potential and Current Liver Cancer Patients in Bangladesh

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Abstract

Liver cancer is a critical global health concern, particularly in developing countries and low- and middle-income countries (LMIC) such as Bangladesh, where the health infrastructure and public awareness are limited. The increasing incidence of liver cancer in Bangladesh is mainly driven by risk factors such as Hepatitis B and C, liver cirrhosis, and nonalcoholic fatty liver disease. Bangladesh faces significant challenges in combating liver cancer, including a lack of systematic data collection, limited healthcare resources, and low public awareness, with 18.8% of Bangladeshi people diagnosed with liver cancer, while 7% of them have a family history of liver cancer and there has been a record of death due to the disease by 64.2%. Provided the increasing smartphone usage in Bangladesh, mobile health (mHealth) applications (apps) offer a promising solution for the management of liver cancer disease. The app was created especially for the Bangladeshi population after it was realized that there were no mHealth apps available in Bangla for liver cancer. A mobile registry app would enable real-time data entry, improve accessibility in rural areas, and integrate with existing health systems. Therefore, the 'LiverCare Registry' app was created to serve as a platform for doctors, researchers, and patients to update medical records, conduct research, and track treatments, respectively. It also includes a chatbox feature for peer communication, enabling patients to connect with others in similar conditions for support. However, the core feature of the app is data collection through a comprehensive liver cancer registration form.

The development of the 'LiverCare Registry' app followed a User-Centered Design (UCD) approach, involving detailed scientific articles that were used for the literature review. The need-finding survey consisted of 24 questions, which helped to gather user requirements and shape the features of the app. Starting with a low-fidelity prototype, the sketches were hand-drawn. The process was then followed by a high-fidelity prototype that was created using Figma, designed with the preferences from users' feedback collected from the low-fidelity prototype evaluation.

Respondents preferred the most common features i.e., Liver Cancer Prevention, Symptoms and Medications, Education on Liver Cancer, Communication with Doctors, and A registry form with an option for uploading medical files. The design focused on simplicity, user-friendliness, and approachability in Bangla. The app offers some more features which are as follows: Reminders of Appointments, Reminders of Medications, Choosing Hospitals, Chatbox, and Research.

The questionnaire of the survey led to useful feedback on several critical points in developing the features for the 'LiverCare Registry' app. Through research, it was found that self-management routines are very important to maintain health by engaging in the app and using it actively. Liver cancer patients or the ones who fear getting infected by the disease need suggestions about which medicine to take according to symptoms (or according to the current stage of cancer) and to study more about liver cancer so that they can prevent it, respectively. Hence, the 'LiverCare Registry' app has featured all the functions that will assist people in preventing and/or maintaining a healthy lifestyle. Continuous user feedback on the low-fidelity prototype has shown that about 92.3% of the participants are eagerly willing to use our app and 7.7% have shown unwillingness to use the app. Future upgrades of the app will emphasize launching it as a final product to be used and add additional features such as personalized recommendations including predictions on whether a user may be at risk of liver cancer and suggestions for treatment plans if cancer is detected, the app will be able to check the validity and authenticity of

medical reports and data can be transferred from doctors to researchers anonymously. All these advancements will be possible through the app of machine learning (ML).

This app provides self-management guidance, setting reminders, scheduling appointments, a list of medications that correspond to related symptoms, uploading health reports and prescriptions, and viewing news, events, and health information. In addition to these, our app also allows patients to communicate with doctors online via video call. Also, there is a feature where the users can communicate with others who have similar health issues. The patients can choose their preferred hospitals for scheduled appointments and treatment in case of emergency. Furthermore, the researchers can use anonymous clinical data and patients' reports for their research purposes through our app. This approach helps the Bangladeshi population to prevent liver cancer and the patients who are already suffering can at least take suggestions from the app to maintain their health and prevent it from getting worse. Furthermore, it potentially serves as a model for similar initiatives globally for liver cancer patients. The 'LiverCare Registry' app ensures aiding in health management, enhancing the understanding of the disease, and promoting a healthier lifestyle for the Bangladeshi people.

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1.1 Background And Motivation

1.1.1 Liver Cancer

Primary liver cancer is a disease in which cancerous cells form in the tissues of the liver [1]. Globally, Hepatocellular carcinoma (HCC) is now ranked as the third leading cause of cancer-related deaths, which, without proper action, can be life-threatening. Most people who are already diagnosed with this disease have potential risks such as liver cirrhosis and chronic infection with the hepatitis B virus (HBV). However, there are some additional risk factors that cause this disease, such as hepatitis C virus (HCV), diabetes, non-alcoholic fatty liver disease, certain inherited liver diseases, obesity, exposure to aflatoxins, and excessive alcohol consumption [2], [3]. As these risk factors are well known, candidates for HCC lead to appropriate early detection through regular surveillance programs [4].

It is more aggressive in patients aged 55 years and older, mainly. In addition, the underlying causes can also be different from those of older individuals and could include inherited genetic risks, liver diseases that are present from birth, or chronic hepatitis infections that started early in life [5].

Currently, researchers are discovering the molecular and immunological characteristics of HCC more than ever before with the development of next-generation sequencing technologies. However, in conjunction with the development of treatments, prevention and spreading awareness of HCC should be focused on worldwide. In a developing country such as Bangladesh, the main obstacles are inadequate health literacy, societal attitudes, and inadequate healthcare infrastructure. Data suggest that HBV is the main cause of 46.9% to 61% of HCC, making it a major public health concern in Bangladesh [6].

1.1.2 Mobile Health (mHealth)

The use of wireless devices like smartphones and tablets has paved the way for mobile health (mHealth), aiming to encourage people to adopt better healthcare habits. Among the many uses of mHealth, educating individuals about preventive healthcare services through mobile devices stands out as the most common. Beyond education, mHealth is also playing an important role in areas such as disease monitoring, tracking epidemic outbreaks, offering treatment support, and managing chronic illnesses. One of the biggest advantages for users is the convenience it offers wearable devices and mobile technologies allow individuals to monitor and manage their health data regularly without the need for frequent visits to healthcare facilities. The variety of available resources is vast as well. A study by the consulting firm *research2guidance* highlighted that by 2017, users could choose from nearly 325,000 mHealth applications available in app stores [7].

With time, these wireless devices are becoming smarter and more interactive, offering a range of communication features that enhance user engagement. In many developed

countries, the push toward launching mHealth solutions has been largely driven by the rising healthcare costs associated with an aging population and chronic diseases. Research suggests that mHealth can significantly improve healthcare services for older adults, especially when it provides tools for self-managed and supervised healthcare. Additionally, mHealth technologies now make it possible to monitor patients remotely through sensors connected to their bodies. Importantly, many chronic illnesses are preventable, and here, mHealth can make a major difference by offering tools and resources that promote healthy living, such as exercise routines, dietary plans, and support for quitting smoking [8].

1.1.3 Human-Computer Interaction (HCI)

Human-Computer Interaction (HCI) is an area of study that focuses on how individuals interact with computer-based technologies. While its early focus was primarily on computers, HCI has grown over time to include a wide range of information technologies, including mobile devices, embedded technologies, and interactive environments [9].

At its core, HCI aims to deepen the understanding of the dynamic and evolving relationship between humans and interactive technologies. It brings together research and design practices, striving to advance both theoretical concepts and practical applications. A key objective of HCI research is to capture the attention of professionals and academics alike, encouraging a deeper exploration of how interactive systems are designed, developed, and used. The field leans heavily on theoretical models, empirical studies, and methodological approaches that guide designers toward creating more effective and meaningful user experiences [10].

In recent years, the rise of natural language technologies, such as chatbots, has begun to reshape the HCI landscape. These tools allow users to interact with systems through more natural, conversational means, making technology more intuitive and accessible. However, while these innovations often aim to create more user-centered designs, they tend to be grounded in Western perspectives, sometimes overlooking the needs of diverse cultural groups. This focus on a narrow human-centered view can unintentionally reinforce existing inequalities in who gets access to and benefits from technological advancements [11].

HCI as a research domain is structured around three major paradigms: empirical, conceptual, and constructive approaches. When evaluating how computers are used today, researchers often combine empirical and constructive methods to solve problems. For example, a constructive-empirical approach might involve developing a new form of interaction and then testing it through user studies to assess its effectiveness and impact. These blended methods not only lead to tangible innovations but also expand our broader understanding of human-technology interaction.

As new perspectives, such as post-humanist thinking, gain ground within HCI, scholars are beginning to question whether these shifts represent true paradigm changes. Are we witnessing a fundamental rethinking of humanity's role in technology, or are we simply reframing old challenges in new ways? While it is too early to say definitively, exploring these new design philosophies pushes the field forward. They encourage us to reflect not only on how technologies are built but also on deeper questions, such as why we build them, who they serve, and what societal, environmental, and ethical impacts they carry.

By using fresh conceptual tools, researchers and designers can trace how ideas evolve, challenging long-held assumptions about usability, interaction, and the central role of humans in system design. As these transitions unfold, they open new possibilities for making technology more inclusive, thoughtful, and impactful across a broader range of human and non-human experiences [12].

1.1.4 User-Centered Design (UCD)

User-centered design (UCD) plays an important role in everyday life by ensuring that user needs are carefully considered during the creation of products and services. It not only helps in refining processes but also guarantees that the results are easy to use, accessible, and ultimately satisfying for users. UCD also emphasizes inclusivity by addressing the specific needs of individuals with disabilities, ensuring that everyone can engage fully with the technology or service provided. Rather than simply understanding user requirements, UCD integrates these needs throughout the entire design journey.

For this approach to be successful, designers must develop a thorough understanding of the people they are designing for, and users themselves should feel connected to and capable of participating in the design process. The technical principles that guide UCD are being formalized by the International Organization for Standardization (ISO) to enhance user experiences at every level. Even before ISO's involvement, developers experimented with usability techniques, although these earlier efforts were often applied in isolation rather than as part of a structured framework [13].

The growing popularity of remote work environments, such as home offices, has also increased the demand for well-designed, multi-user Information and Communication Technology (ICT) systems. Similarly, healthcare sectors are adopting technologies like e-health and telehealth to improve access to medical services. These tools allow patients and healthcare professionals to stay connected, enabling more frequent health monitoring and support regardless of physical distance [14].

1.1.5 Importance of mHealth App in Liver Care

mHealth is an expanding field that uses wireless communication devices such as tablets and smartphones to improve accessibility and healthcare delivery. In the context of liver cancer, which is often identified in an advanced stage, mHealth technologies facilitate better, timely intervention, remote patient monitoring, and improved clinical oversight. Smartphone capabilities can lead to the development of mHealth ecosystems with real-time data sharing and app-based interfaces where doctors can analyze patient records anywhere in the world. This technology facilitates healthcare work, patient participation, and improves efficiency by making it easier and faster [15].

mHealth provides novel strategies for the detection, tracking, monitoring, managing, and control of infectious diseases. It also contributes more efficiency to healthcare systems when integrated with internet-enabled medical equipment. Health tracking tools can help contribute to the early detection of liver cancer through risk-based algorithms, symptom tracking, and automated reminders for routine screening. As a result, mHealth can improve clinical outcomes, increase patient engagement, lower healthcare costs, and simplify the treatment process. However, to understand the cost-effectiveness of mHealth, a thorough evaluation requires structured evaluations, proper research, and a parallel focus on public education. Government policies must support this process to promote integration, sustainability, and ensure long-term success. For this study, quantitative methods and network visualization techniques were applied to research trends, app research, collaboration patterns, areas of particular interest, and themes in the field of mHealth apps. Research on mHealth apps is a new and exciting topic in the world with vast areas that enhance healthcare delivery and advance global health objectives [16].

1.2 Problem Statement

In Bangladesh, liver cancer remains a major health concern, particularly due to the heavy burden of HCC and the ongoing challenges related to its diagnosis, treatment, and prevention. HCC is currently the third most common cancer in the country, following lung and stomach cancers. A significant factor behind this high incidence is HBV infection, which accounts for around 66% of HCC cases in Bangladesh. The estimated prevalence rates for HBV and HCV are approximately 5.4% and 0.84%, respectively. Liver diseases are also a significant reason for hospital admissions, making up about 8% to 12% of cases in the medicine wards of public medical colleges.

Like the rest of the world, Bangladesh faces a growing cancer crisis. Globally, HCC is the sixth most common cancer and makes up about 7% of all cancer diagnoses. In Bangladesh, HBV remains a major cause of chronic hepatitis and liver cancer. However, with the introduction of the HBV vaccine under the Expanded Program on Immunization (EPI), the rate of HBV infections has been gradually declining. There is hope that with continued efforts, Bangladesh can achieve the practical elimination of HBV by the year 2030 [17].

1.3 Research Gap

A research gap is an area within a subject or field where there is a lack of sufficient information, making it difficult to draw firm conclusions. Identifying these gaps plays a key role in the research process, helping researchers to frame more precise and meaningful research questions. It also directs attention to areas that need further exploration and deeper understanding. Even when a particular disease has been widely studied, there can still be missing pieces, such as limited knowledge about its fundamental causes or biological mechanisms. In this context, the significant research gaps that can be identified are:

- There was no previous application available for Bangladeshi people to prevent liver cancer.
- Insufficient awareness regarding HCC.
- No previous application in the Bangla language for HCC.

1.4 Research Objectives and Questions

1.4.1 Research Objectives

The primary objectives of this research were:

- To design and develop a mHealth app in Bangla language following the UCD methodology.
- To help Bangladeshi people manage themselves emotionally through the HCC smartphone app.
- To educate the general people of Bangladesh about liver cancer and its implications.

1.4.2 Research Questions

A research question (RQ) serves as the foundation of a study or project, guiding the investigation toward a specific answer presented through the thesis statement. It typically highlights a problem or issue that the research seeks to resolve by analyzing and interpreting collected data[18]. A well-formed research question not only sets the boundaries for the study but also provides direction for how data should be gathered and examined. To address the research gap, we formulated 2 RQs, they are:

- **RQ1:** What are the types of mHealth apps that intend to help Bangladeshi people manage liver cancer?
- **RQ2:** How do these mHealth apps support liver cancer patients mentally?

1.5 Research Outcome

The purpose of the 'LiverCare Registry' app is to help potential and current liver cancer patients to manage the disease and stay healthy. All the features will be in Bangla as this app is made only for the population of Bangladesh, where people mostly speak and understand Bangla. By systematically reviewing the scientific literature and developing a comprehensive conceptual framework, we propose that the app 'LiverCare Registry' addresses the main health problems related to liver cancer and helps people efficiently. The research explores feature selection, developing a low-fidelity prototype and then taking feedback, and then eventually developing a high-fidelity prototype using Figma, a website for designing the user interface (UI) of the app. The research journey will ensure that the app is tailored to the specific needs of the target audience. A flowchart describing the process is shown in Fig. 5.

1.6 Report Outline

Chapter 1 (Introduction):

The introduction part provides an overview of HCC being the deadliest disease that is the sixth most prevalent cancer globally, and represents 7% all cancers, and the importance of mHealth, UCD, HCI, and the idea of using mHealth apps to manage liver cancer. This section also highlights the importance of HCI and the reasoning behind this research, alongside recognizing the research gap. RQs were developed to summarize our findings during our review of the literature for this research.

Chapter 2 (Literature Review):

This section contains the systematic literature review work done using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. From an initial set of 50 articles, 11 were selected following the inclusion criteria. Two research questions (RQs) were used to guide the analysis of the selected studies.

Chapter 3 (Methodology):

The methodology part of the paper consists of what is UCD method and how the UCD method is used in this process. The process of making the prototype is also described in this part, such as gathering requirements through literature review, need-finding survey

analysis, where key features were found out, brainstorming, and finalizing the key features. Also, the description of the development and evaluation of low-fidelity prototypes and high-fidelity prototypes is mentioned here.

Chapter 4 (Prototype and Its Features):

This chapter contains an elaborated description of what a prototype is and the key features of 'LiverCare Registry', which are: *" Homepage"*, *"Sign Up"*, *"Sign In"*, *"Liver Cancer Registry"*, *"Education on Liver Cancer"*, *"Liver Cancer Prevention"*, *"Doctor"*, *"Hospital"*, *"Symptoms and Medication"*, *"Research"*, and *"Chatbox"*. It also contains visuals of high-fidelity prototypes and describes the process of going through the prototype.

Chapter 5 (Results and Analysis):

This section contains the information on primary data collection to figure out the preferences and needs of the users. It also contains visuals of the percentage of people who liked which feature of the app the most and expressed their willingness to use the app.

Chapter 6 (Discussion):

This part discusses limitations and challenges faced while surveying. The reasons were as follows: limited participants, response issues, language barrier, lack of rural participants, and problems with accurate data input.

Chapter 7 (Conclusion and Future Work):

This part gives a summary of what the app will be like in the future. For instance, how the app is going to help the users more efficiently after the application of machine learning. Also, this part gives a summary of all the chapters that are present in the above, with a description and process of the app's development.

- **Appendix A**: This section provides a comprehensive list of all abbreviations used throughout the research.
- **Appendix B**: This part contains a list of published papers that have resulted from this work.

2 Systematic Literature Review

Systematic Literature Review (SLR) is a step-by-step approach to exploring comprehensively all relevant research on a specific topic or research question. Though general literature reviews are often more narrative and biased, an SLR adheres to a predefined protocol prescribing the search strategy, the inclusion and exclusion criteria, the methods for extraction, and the analysis of data. Therefore, it has been regarded as comprehensive, transparent, and replicable. The SLR was an integral part of accumulating available knowledge on liver cancer and its critical analysis. It is a well-articulated mechanism of SLR to identify the major trends, gaps, and areas of consensus or disagreement in research evidence. The findings of this have provided us with a sound footing in our work and enabled us to underpin our study with the most current and relevant studies. Gained insights from SLR, then helped in refining our RQs and guided methodology, hence giving a definite direction to the succeeding phases of our research on liver cancer.

While there are mobile app-based interventions for different types of health issues, it was found that there was no specific mHealth app that only dealt with liver cancer, a deadly disease. Hence, we conducted a systematic literature review on mHealth apps that take medical information from people through a registry and help treat the disease. In this work, we specifically investigated the advances in mHealth apps using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method of systematic review [19]. Following the PRISMA method, our initial search of relevant research gave us a starting number of 62 articles. We then went on to select 23 articles for our analysis after multiple stages of evaluation. We developed two RQs to summarise our findings, which are listed in Table 2.1. Our findings show that in developed countries, registries are used to collect information about people's health. The registries are in the form of questionnaires. The findings will be summarized in this single review.

2.1 Materials and methods

The goal is to analyze and identify how the registries work in developed countries to take medical information from patients, so we started identifying relevant studies from PubMed, PMC, BioMed Central, and ScienceDirect. These were selected due to their comprehensive coverage of healthcare and information technology, as well as their established use in systematic literature reviews on similar domains and topics. This strategic choice of reputable academic sources aimed to facilitate a thorough exploration of existing research that aligned with the main concept of the study. The creation of two RQs that will direct the steps from research methodology to reporting can be used to carry out the data management process. Table 2.1 shows the outlines of the RQs developed. Our search for articles was based on abstracts and titles. We adhered to the PRISMA approach for this systematic review, as shown in Fig. 1.

2.1.1 Search Strategies

To begin our search for relevant research papers, we had to select some keywords and generate relevant search strings. The keywords "Liver Cancer National Registry", "Liver Cancer", and "National Registry" were combined with "mHealth", "smartphone", and "app" using the Boolean operators. The exact string that was used:

Table 2.1: Research Questions Developed And The Rationale Behind Them

ID	RQ	Rationale
RQ1	What are the types of mHealth apps that intend to help Bangladeshi people manage liver cancer?	Several apps have been developed to help liver cancer patients. These need to be understood to identify the trends, gaps, and potential areas for improvement. Most apps are smartphone-based, with Android and iPhone Operating System (iOS) versions.
RQ2	How do these mHealth apps support liver cancer patients mentally?	These apps offer psychosocial support modules addressing anxiety and depression associated with chronic liver disease.

("Liver Cancer" OR "National Registry" OR "Liver Cancer National Registry") AND ("mHealth" OR "mobile health" OR "smartphone" OR "mobile app" OR "application")

After running this query through the databases, we first received a total of 62 relevant articles. We then proceeded to exclude duplicate articles from the various databases and manually checked the rest of the articles based on the inclusion criteria.

2.1.2 Inclusion Criteria

The filtration procedure begins with considering certain elements that are crucial to our research and are chosen to utilize the inclusion criteria to proceed with the study. The inclusion criteria are:

- Focuses on mHealth-related apps.
- Concentrates on liver cancer-related apps.
- Emphasizes national registry-related apps.
- Deals with liver cancer national registry-related apps.
- Mobile app-based.

2.1.3 Exclusion Criteria

The exclusion criteria exclude those elements that are not taken into account for this investigation. The exclusion criteria are as follows:

- Review papers.
- Short papers.
- Papers published before 2009.
- Not written in English.

2.2 Data Extraction

Our next goal was to investigate the full-text articles and extract relevant information to assess their efficacy in helping liver cancer patients. We defined some categories to extract the data accordingly from the selected articles and followed the data extraction theme as shown in Fig. 1. A summary of the data extraction themes is given below:

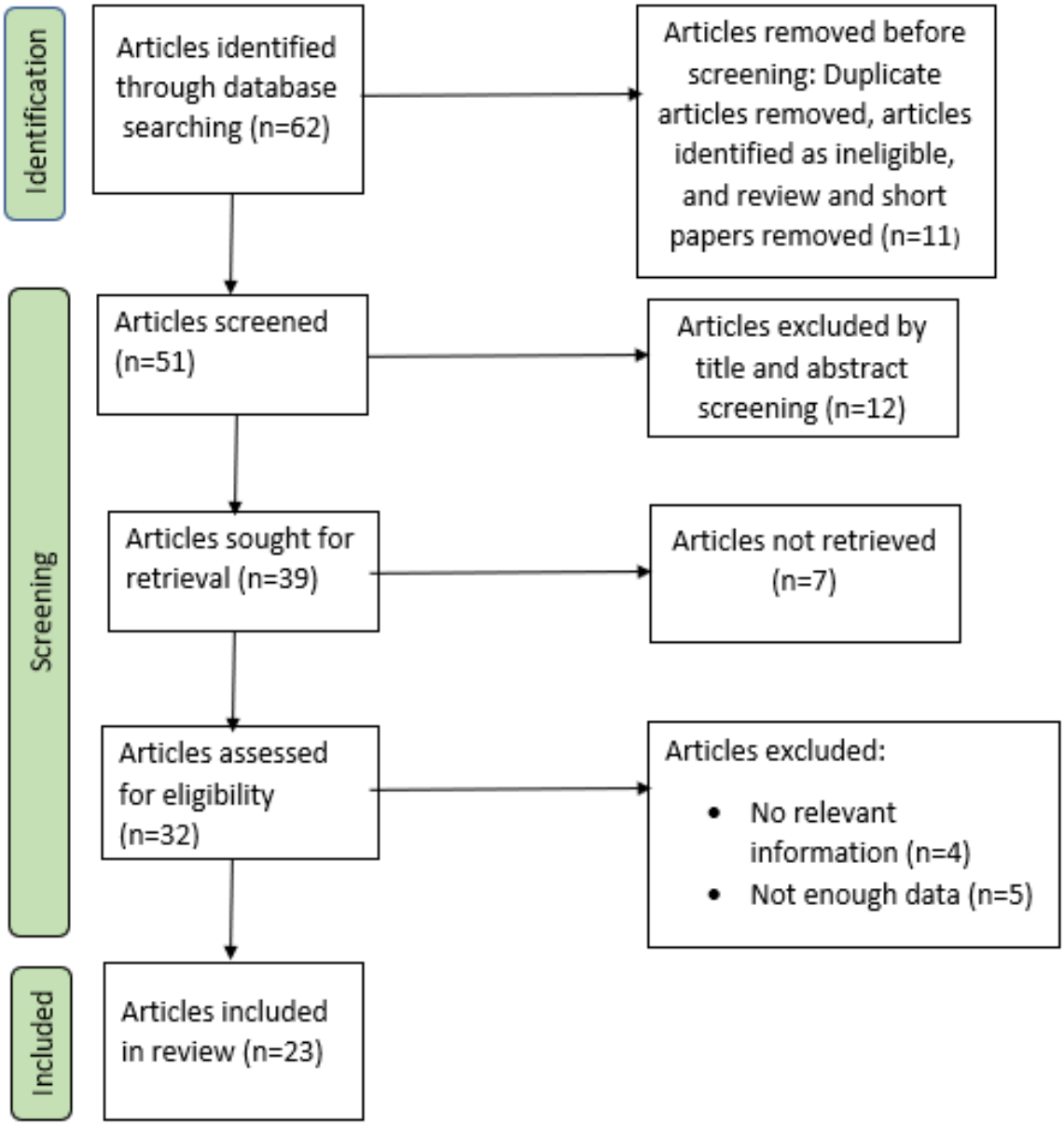

Figure 1: PRISMA flowchart for the literature search process

Topical Association

- **Title Based:** For the purpose of eliminating the duplicated, short, and review papers, titles were used here as the first phase of the study was title screening.
- **Keyword-Based:** Papers were searched by the keywords that were used by the authors.

Publication Profile

- **First Author Location:** To analyze which countries are interested in and working on the topic of the Liver Cancer National Registry.
- **Publication Type:** To track how many conferences and journals have already been published regarding this study.
- **Publication Year:** To understand the trend of publishing years, the year is kept on track.

Research Objectives

- **Health Issues:** This section helps to list the health conditions addressed by the authors.
- **Type of Treatment:** This will enable us to analyze what medications are provided the most and how effective they are.
- **Mode of Communication with Participants:** This section will help to analyze users' perspectives on using the app or the medications suggested by the authors.
- **Findings:** This data will help assess the effectiveness of mHealth apps in the management of liver cancer.

Mobile App

- **Features Available:** This section will help to evaluate the features that are effective in the liver cancer period.
- **Platform:** This makes it easier to identify a specific group of mobile phone users.
- **Uses Period:** This section helps to determine whether users spent a significant amount of time using the app or not.

2.3 Publication Analysis

The mHealth apps promote community involvement as well as provide crucial health information regarding social support networks. These apps allow consumers to make sensible choices and keep an eye on their health by collecting information on their overall well-being. These smartphone apps can also be advantageous during medical treatments and in promoting active lifestyles such as consistent vigorous physical activity, consuming nutritious meals, controlling body weight, and regulating obesity. In this regard, mHealth apps provide innovative opportunities for the management of chronic health conditions and healthcare services generally. Below are the descriptions of some apps that were found during the literature review.

The effect of a smartphone app was evaluated on patients with primary liver cancer, called 'Shared Decision-Making Assistant' in a quasi-experimental study conducted in China. The app was designed for Android and was based on the Ottawa Decision Support Framework. The purpose of the app was to guide informed patients through complicated treatment decisions by providing a structured decision-making path, clear information, and interactive tools. This quasi-experimental study was conducted in a major hepatobiliary hospital where 180 patients were involved and divided into intervention

and control groups. The results indicated that the users of the app experienced considerably lower decision conflict, greater readiness for decisions, improved self-belief, greater satisfaction, and better knowledge about liver cancer treatment, although no particular difference in decision regret was found after three months. Therefore, the study suggests that mHealth tools like this app can make patients powerful, improve decision quality, and potentially support national liver cancer management strategies, especially in settings where healthcare services are poor [20].

A randomized trial protocol was conducted on an app called 'mISH' to investigate the effectiveness of an mHealth-based exercise intervention to improve insulin sensitivity among patients with HCC disease and insulin resistance after anticancer treatment. This study was conducted at Samsung Medical Center in South Korea, the test introduces a smartphone app linked with a wearable device designed particularly for liver cancer patients. The app provides resistance and personal aerobic exercise plans, tracks physical activity and diet, manages medication timetables, and offers health consultations. 80 patients in the initial stage of HCC remission are arbitrarily assigned to an intervention group using the app or a control group receiving usual care. Each group had 40 patients. The main goal is to determine whether the mHealth program can significantly normalize insulin resistance, whereas secondary outcomes include changes in body composition, physical fitness, and quality of life. Although this study is not like the national registry, it shows how digital health tools can support liver cancer management and generate structured patient data, which can ultimately contribute to future national registry initiatives, working towards improving outcomes for HCC survivors [21].

Another randomized controlled test protocol was conducted to evaluate the effectiveness of a mHealth intervention that aims to improve liver cancer screening among high-risk populations, developed in Hunan Province, China. This intervention uses the 'WeChat' app to provide customized education on health, motivational content, and reminders of screening over a time period of six months. The participants are the ones at risk for liver cancer due to factors such as alcohol use, hepatitis B/C, or family history. In this study, an intervention group receiving mHealth-based support and a control group receiving standard health education are compared. The results will be assessed through self-belief, social support measures, and screening adherence. Although this study is not exactly a national registry, it shows how mHealth tools can support behavior change and early detection in at-risk populations, generate structured data, and serve as a flexible model that could inform future registry-based programs or improve national liver screening strategies [22].

A smartphone app named 'Quit2Heal' was evaluated, which was designed to help cancer patients quit smoking, through a pilot randomized testing comparing it with the National Cancer Institute's *QuitGuide* app. The study highlights the broader challenge of combining digital health tools into cancer care that is relevant to liver cancer registry efforts, working towards tracking and improving patient end results, while primarily focusing on smoking cessation among cancer patients including those with lung, breast, and other cancers. The experiment found that 'Quit2Heal' was more acceptable to participants and demonstrated higher rates of satisfaction compared to *QuitGuide*, with a trend towards better quit smoking rates (20% vs 7%). The study underscores the prospects of mHealth interventions to support cancer patients in modifying risk factors such as smoking, that could be adjusted for liver cancer registries to monitor and improve patient adherence to lifestyle changes after diagnosis, although the study's main focus is not on liver cancer. In the paper, there is a call for large experiments to confirm effectiveness, a principle applicable to registry-based interventions for liver cancer [23].

The protocol for 'iCare' is a self-directed online program. It was designed to improve

the health and well-being of patients suffering from upper gastrointestinal (GI) or hepato-pancreato-biliary (HPB) cancers, including liver cancer, and their informal caregivers. The study of Phase II randomized controlled trial works towards accessing the feasibility, acceptability, and preparatory efficacy of 'iCare' by enrolling 162 carers and 162 patients, recruited via the Upper Gastrointestinal Cancer Registry (UGICR), hospital clinics and social media. Participants will be randomized to access 'iCare', which offers adjusted information, symptom psychological support to track symptoms, or usual care, with results measured at enrollment, 3 and 6 months. Recruitment rates and engagement with the platform are included in the primary metrics, while secondary results emphasize quality of life (QoL), unmet needs, and caregiver burden [24].

2.4 Literature Search Outcomes and Characteristics of Included Studies

After a comprehensive search in Google Scholar, PubMed, ScienceDirect, ResearchGate, and IEEE by implementing the specific phrase and stringent inclusion and exclusion criteria that were developed, initially, 62 papers were found. Title screening was an intensive step in the investigation's second segment. During this segment of the project, redundant documents, review articles, as well as short papers were meticulously identified and eradicated. This comprehensive technique was crucial to maintaining the credibility and emphasis of the research, which enabled the execution of a higher level of accuracy and reliability analysis in the subsequent stages. After completing the second stage, there remained only 51 papers. The third segment of the research was abstract screening, which minimized the selection even further. Then, the relevance and effectiveness of the study were evaluated by analyzing every single one of the 39 abstracts according to the specified inclusion and exclusion criteria. Later, the papers were minimized to 32 only due to the procedure of a comprehensive screening approach that eliminated study findings that did not quite correspond with the indispensable specifications. Lastly, the final stage of the research was a thorough full-text screening of these 23 papers. In this phase, an encompassing data extraction procedure was conducted after checking every single paper meticulously to ensure it adhered to the requirements, and then, finally, these 23 papers were finalized, and they were utilized for the ensuing analysis tasks.

The number of papers published from 2009 to 2025 is illustrated in Fig. 2. Although no specific time was fixed during the paper-searching period, only articles from 2016 to 2025 were discovered, which may be a sign that there is still a dearth of recent and limited research on this subject. A few articles that were published before 2009 were not included in the final list, as they were deemed irrelevant to our search parameters. As can be observed from the figure, 2022 had the greatest number (n = 7) of relevant research papers. After 2022, the following year, 2024, had the next-highest number of publications (n = 4). 2025 had the third-highest number of articles (n = 3). The years 2016 and 2021 had the comparatively less number of articles (n = 2). The lowest number (n = 1) of articles was published in the years 2009, 2013, 2018, 2020 and 2023.

To determine where the majority of research on this topic has been conducted, Table 2.2 displays the publications that were published in each nation according to the institution locations of the first authors of the 23 papers selected for the systematic review. This was done to identify the nations that have generated the most studies on this topic. The table shows that, with a total of 23 publications, the vast majority of the study was conducted in China (n = 6). Korea and the US each have 4 articles, Bangladesh has 3 articles, and the UK has 2 articles, while Australia, Gambia, Spain and Sri Lanka have

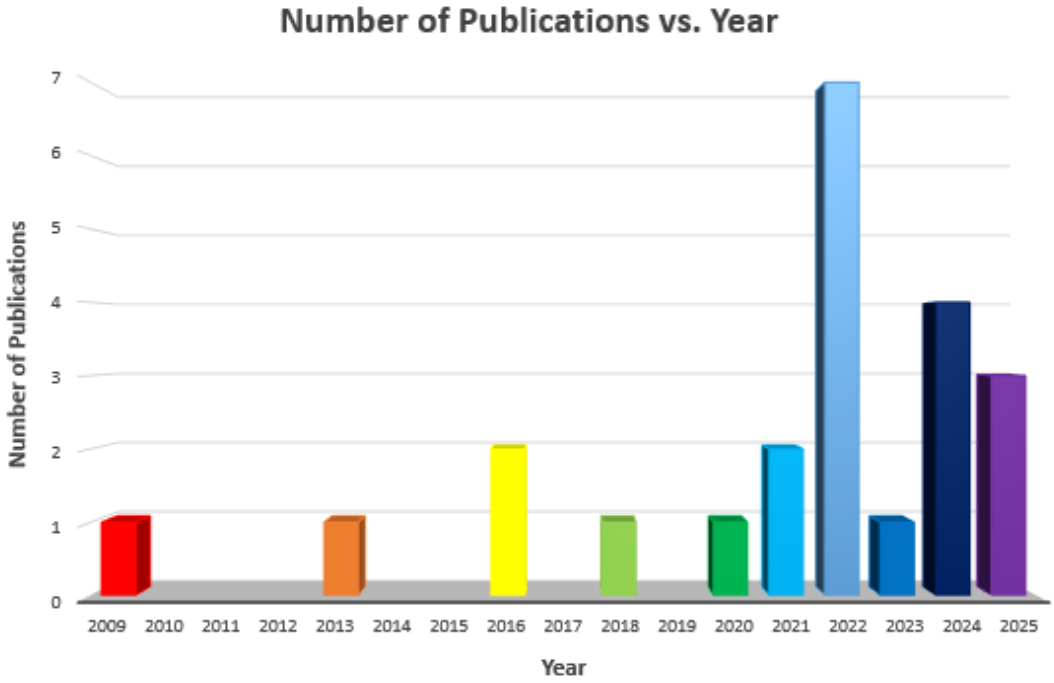

Figure 2: Year-wise published number of articles out of the 23 selected articles for review

conducted relatively little research on this topic, each producing just 1 literature paper.

Table 2.2: Institution location (country) of the articles' first authors

No. of Articles	**First Author's Country**
6	China
4	South Korea and the United States
3	Bangladesh
2	The United Kingdom
1	Australia, Sri Lanka, Spain and Gambia

To demonstrate more clearly how research on this topic has been dispersed around the world, we have constructed a map using the same data, as shown in Fig. 3. The map is generated so that countries with 23 papers are highlighted by a higher intensity color.

All of the author keywords included in the reviewed articles are visually represented by the word cloud in Fig. 4. The size and strength of a word inside a text indicate its frequency and importance. The most often used author keywords across the reviewed publications are mhealth, hepatocellular carcinoma, and liver cancer, according to the word cloud. This indicates that these are the primary concerns of the mentioned papers. The creation of mHealth solutions has been addressed by other terms in the word cloud, including exercise in cancer, cancer screening, mobile, application, and app.

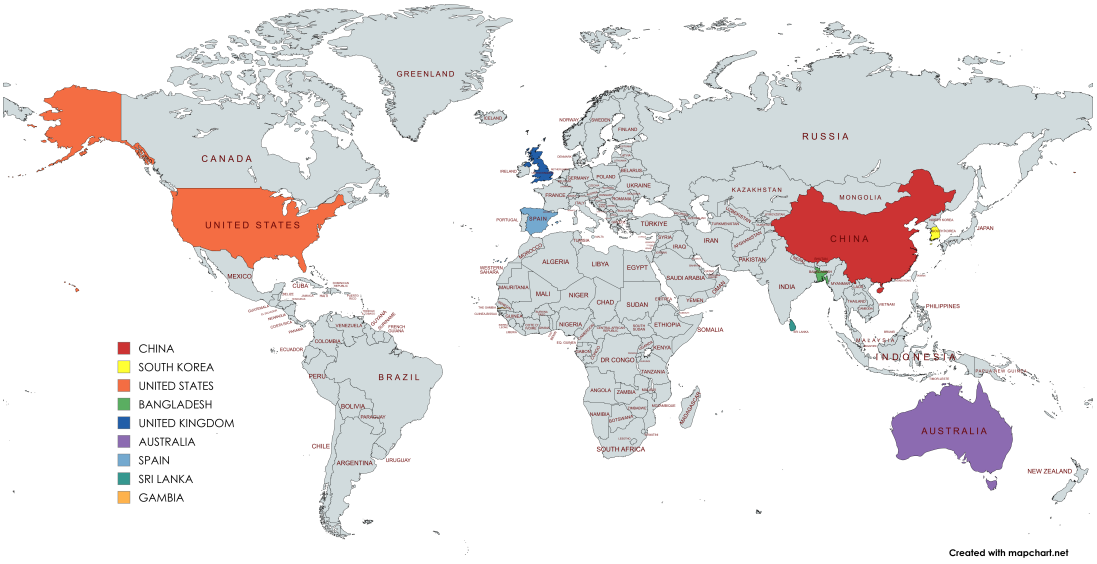

Figure 3: Map representing the institution location (country) of the articles' first authors

Figure 4: Word cloud based on author keywords available in reviewed articles

2.5 Addressing RQs

2.5.1 RQ1: What are the types of mHealth apps that intend to help Bangladeshi people manage liver cancer?

Several mHealth apps were found in our review, with each being a little different than the other. A total of 5 apps were found among the 23 articles, and all of them are smartphone-based apps. The purpose of the apps is as follows. Firstly, 'Shared Decision-Making Assistant' is an app to be used on Android phones, and it aims to guide informed patients through complicated treatment decisions by providing a structured decision-making path, clear information, and interactive tools. Secondly, the 'mISH App' is a mobile exercise intervention for HCC patients that aims to improve insulin sensitivity among patients and insulin resistance after anticancer treatment. The main goal is to determine whether the mHealth program can significantly normalize insulin resistance. Thirdly, the 'WeChat-

Based Screening Support' app aims to increase liver cancer screening rates among at-risk individuals. Fourthly, the 'Quit2Heal' is an app that aims to help cancer patients stop smoking. Last but not least, 'iCare' a self-directed, interactive online program is a smartphone-based app that aims to improve the health and well-being of patients suffering from upper gastrointestinal (GI) or hepato-pancreato-biliary (HPB) cancers, including liver cancer, and their informal caregivers.

Also, we found more apps from Google Play Store and they were as follows: The 'Liver Cancer Manager' app is an iOS-based app that offers a daily journal, self-management guidance, setting reminders, and scheduling appointments. The 'LiverWell' app is an android-based app that offers self-management guidance, setting reminders, scheduling appointments, and uploading health reports. The 'Liver Health App' offers self-management guidance, a daily journal, and access to news, events, and health information. Also, the 'My Liver Care' app is an android-based app that offers self-management guidance, a daily journal, setting reminders, and creating a list of medications. In Table 2.3, the list of all these apps with their corresponding features and citations is listed below.

2.5.2 RQ2: How do these mHealth apps support liver cancer patients mentally?

Along with physical treatment, mHealth tools are also beneficial for psychological treatment for liver cancer patients. Anxiety, uncertainty, and emotional distress by educating patients, using interactive decision aids, and individualized health plans are reduced by these mHealth tools. Decision anxiety is reduced by tools like the 'Shared Decision-Making Assistant' by simplifying treatment options, and emotional concerns like stigma, depression, and shame concerning cancer and smoking are directly addressed by 'Quit2Heal'. The 'iCare' app goes one step further by offering routes for both caregivers and patients, e.g., recording emotional needs and connections to psychosocial support details. Also, the 'WeChat-Based Screening Support' App provides personalized motivational messages to calm its users down emotionally. Even physical recovery-focused apps like 'mISH' indirectly benefit mental health by offering structure, motivation, and a sense of being able to manage one's recovery. Cumulatively, the applications enable the patients to feel less isolated, more informed, and emotionally nurtured throughout their cancer journey. These apps and their corresponding features for psychological treatment are listed in Table 2.3 of **RQ1**.

Table 2.3: The list of apps and their corresponding features for liver cancer patients.

Name of the App	Citation	Features
Shared Decision-Making Assistant	[20]	Personalized guidance through 12 liver cancer treatment options; visual tools (diagrams, videos, animations); interactive quizzes; decision tracking; options for family involvement; simple layout for low health literacy.
mISH App	[21]	Wearable integration; daily activity tracking (aerobic + resistance); diet monitoring; medication reminders; motivational coaching; health consultations.
WeChat-Based Screening Support App	[22]	Health education and prevention content; automated screening reminders; personalized motivational messages; behavior prompts based on Fogg's Behavior Model; delivered via 'WeChat'.
Quit2Heal App	[23]	Coping skills for smoking urges and cancer-related distress; quit plan with progress tracking; interactive exercises; fictional survivor testimonials; educational content on smoking and cancer; achievement badges; communication tips for patients.
iCare App	[24]	Separate modules for patients and carers; multimedia resources (videos, podcasts, articles); need-based content navigation; symptom and emotion tracking; weekly email reminders; connections to support groups; healthcare use and cost tracking.
Liver Cancer Manager	[25]	Tracking daily symptoms and progress; medication and treatment management; images of visible symptoms upload capability; connectivity with healthcare provider; educational resources (videos, articles, journals); in-app guidance; @point reward system; health app integration
LiverWELL	[26]	Reminders for medications; scheduling appointments; tracking test results; uploading radiology reports; keeping note of all significant information about health; educational resources; multilingual support (English, Arabic, Thai, Simplified Chinese, Vietnamese, Burmese)
Liver Health	[27]	Diet and liver health guidance; a risk assessment tool; BMI calculator with instant feedback; a patient portal for liver function tests (LFTs); a portal for healthcare professionals; up-to-date liver blogs and videos; easily share the app with people; information for common liver diseases; provide tips for liver care; an educational liver game like a quiz; access for consultation with experts
My Liver Care	[28]	Monitoring health trends like BP, weight, etc., regularly; record medical reports; medications management; schedule appointments

3 Methodology

3.1 UCD Approach

The 'LiverCare Registry' app was developed using the UCD approach that involved a thorough examination of several studies. The design process included a review of the literature, a need-finding survey, and the development of a low-fidelity prototype, followed by a high-fidelity prototype. Published publications and different types of apps related to liver cancer were analyzed, 24 survey questions were added to the Google Forms, and user feedback was collected for requirements. Hand sketches were made to test functionality, and then the low-fidelity prototype was refined into a high-fidelity version with detailed features. The high-fidelity prototype was designed using Figma, allowing for a complete visualization of the app's features and user experience.

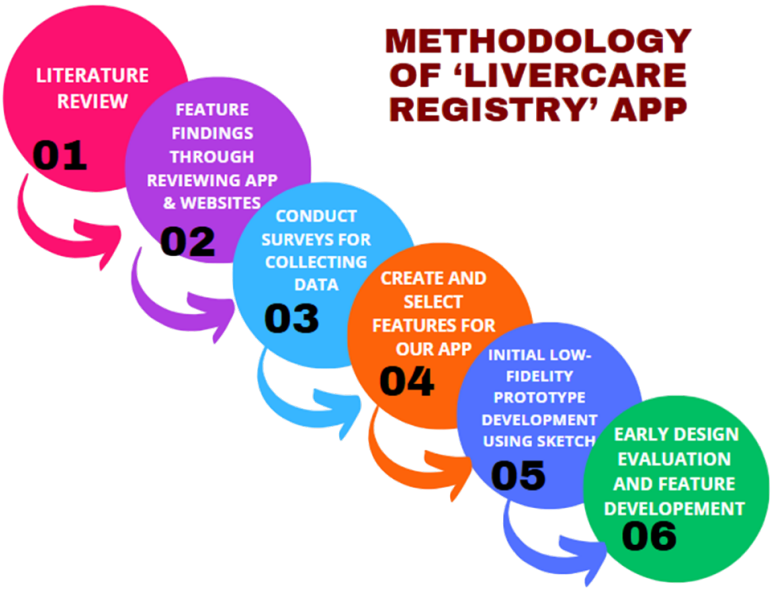

Figure 5: Components and workflow of the UCD method.

3.2 Requirement Gathering

In the initial stage, we emphasized extracting design requirements by reviewing relevant literature and identifying key features primarily focused on the liver cancer national registry to better understand how it works or why it is crucial for a nation, as our main priority is to create a national registry for the liver cancer patients in Bangladesh [29], [30], [31], [32]. Then we also reviewed some articles that are entirely focused on the different types of national registries to better understand how a national registry plays a

significant role in improving the overall condition and why it is crucial for a nation [33], [34], [35], [36], [37], [38], [39], [40]. We gained a better understanding of the overall cases of liver cancer, identified the causes of the disease, the age and sex of the affected people, and found out the survival rate and the death rate in different demographic regions in the world [41], [42], [43], [44], [45], [46], [47], [48]. Moreover, we came to know the treatment method and medication that a liver cancer patient goes through based on the stages of liver cancer, that is, very early stage (stage 0), early stage (stage A), intermediate stage (stage B), advanced stage (stage C) and end-stage (stage D) [49], [50]. Then we reviewed many apps, websites and research papers. We found many similar types of apps to determine the prototype of our app [51], [52]. Several apps related to liver cancer have emerged in recent years, which we compared with our potential features found through brainstorming. All of the features of the 'LiverCare Registry' app compared to the features of numerous apps are shown in Table 3.1.

Table 3.1: Comparison of the Features of Numerous Liver-Related Apps and Our App 'LiverCare Registry'

Name of the Features	**Shared Decision Making Assistant**	**mISH App**	**WeChat-Based Screening Support App**	**Quit2-Heal App**	**iCare App**	**Liver Cancer Manager**	**Liver-WELL**	**Liver Health**	**My Liver Care**	**LiverCare Registry (Our App)**
Daily Journal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Schedule Appointment	✗	✗	✓	✗	✗	✓	✓	✓	✓	✓
Reminders for Appointment	✗	✗	✓	✗	✗	✓	✓	✗	✓	✓
Reminders for Medications	✗	✓	✓	✓	✓	✓	✓	✗	✗	✓
List of Medications	✓	✓	✗	✗	✓	✓	✓	✗	✓	✓
Self-Management Guidances	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Communicate with Doctors Online	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
Choose the Preferred Hospital	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓
Upload Medical Reports	✗	✗	✗	✗	✗	✓	✓	✗	✓	✓
View Liver Health Information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Utilize the Clinical Data for Research	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓
Cost Efficiency	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

3.3 Need-Finding Survey

The need-finding survey aimed to understand the preferences and needs of liver cancer patients for a mHealth app. A total of 53 people participated in the need-finding analysis survey. The participants were between 19 and 60 years old, with a mean age of 43.25 years and a standard deviation of 13.34 years, among whom only 10 were patients with liver cancer at Sir Salimullah Medical College Mitford Hospital, Dhaka, Bangladesh. The rest of the 43 participants who responded to the survey were not exactly liver cancer patients. They were random patients with other diseases but helped us by sharing the information of their relatives who are suffering from liver cancer (they are admitted to some other hospital), and some just shared a family history of having a liver cancer patient in their family who eventually died. The target participants were mainly Bangladeshi liver cancer patients who owned a smartphone (or at least had an idea about it) and had an idea about using apps (in general). The survey, which took about 10 minutes to complete, included questions about the family history of anyone suffering from liver cancer, and then some questions based on the features of the app. In addition, they were also asked if they would be interested in using an app that collects data about their disease and helps them get better guidance on preventing or treating it and if they have any experience with using mHealth apps. The format of the survey questions had multiple-choice questions, 5-point Likert scales and checkboxes, short answers, and long answers. All of this resulting data was collected in Google Forms and was stored and analyzed using Google Sheets.

All the participants expressed that they would be very glad to use an app that helps them prevent such a detrimental disease, and the ones who are suffering from it currently would like to use it to at least lessen the pain of the disease. When they were asked what features they would like to see in such an app, 81.1% said they would like a feature that gives them guidelines on how to prevent the disease, 73.6% said they would like a feature that suggests which medicine to take according to which symptom in emergency cases such as if a person cannot visit a doctor, 69.8% said they would like a section that educates them about the disease, and 60.4% said they would like a form that takes their medical information for proper diagnosis. This survey helped to shape the mHealth app by providing insightful information about the unique requirements and preferences of people with or without liver cancer, and partially addresses questions where key features are found. Detailed results analysis is described in Section 5.1.

3.4 Brainstorming

Brainstorming sessions were held to create ideas on how to build the app so that it can help patients and prevent disease, to maintain a healthy lifestyle. The main motive was to create a registry form that would take medical information from people for a proper diagnosis of the disease. In order to find research gaps and to obtain an understanding of this concept, the initial steps were to research the topic through the Internet and to study scientific papers. The main goal of this approach was to find out how such an app would work and how data could be collected and used for a proper diagnosis.

A low-fidelity prototype was created as a result of brainstorming and drawing sessions and was later evaluated by the responses of the participants. Google Forms was used to collect responses. The needs and preferences of the app's target users were liver cancer patients, especially those who have smartphones and at least have an idea of how to use an app. In order to help liver cancer patients manage their cancer symptoms and ease their suffering, the app was designed with user feedback, taking into account their particular

requirements and concerns. Also, to prevent the disease from attacking healthy people, the app was customized in that way to help maintain a healthy lifestyle.

3.5 Low-Fidelity Prototype

To efficiently visualize concepts and gather feedback, a low-fidelity prototype is essential in the early design stage. These types of prototypes can be sketches, wireframes, storyboards, interactive prototypes, or paper prototypes, among other formats. Hand-drawn images, or sketches of the user interface, are quick and easy to create and change. Additional components made from paper cutouts that users can change and interact with are included in the paper prototypes. Sketches, also known as simple designs, which focus more on component placement and navigation than advanced design, can be created manually or digitally. For the creation of the 'LiverCare Registry' app, the low-fidelity prototype was drawn by hand.

In our low-fidelity design process, we began with basic sketches to visualize the interface. In the beginning, we had to make significant changes as we found the designs lacking in several aspects. Our main goal was to enhance the layout and functionality to create a more intuitive and user-friendly interface. We aimed for simplicity in the design to make sure that users could easily use and interact with the features in the app. With a clean and efficient layout, we aimed for the main features to be placed in a way that made them visible and easy to access.

The registry form, which is the main feature of the app, was one of the most important design additions. This is because it is the one that collects medical information from people for further diagnosis. So, questions had to be made accordingly. In the prototype, a "Reminder" was included, prominently placed to keep it in view so that the user can stay aware of planned tasks or vital alerts. Other additional features are placed on the dashboard as buttons so that users can explore all the features and get personalized recommendations.

The authors gathered ideas for the 'LiverCare Registry' app prototype through literature reviews, survey analysis, and brainstorming sessions. The initial sketches prioritized key features and user flow; they were later updated in response to feedback from the participants. Hand-made paper-sketched prototypes were created with several sketches, with pen and paper. Progressive changes to the prototype were made after the evaluation of the low-fidelity prototype, which was conducted to get feedback. When an updated version with more interaction was required, the prototype was developed into a high-fidelity prototype.

3.6 Evaluation of Low-Fidelity Prototype

Evaluation of low low-fidelity prototype for the management of health to prevent or reduce the pain of liver cancer symptoms in Bangladesh was conducted through the use of Google Forms and data stored in Google Sheets. Before starting the analysis, participants received information about the survey form and gave their consent. Likert scales, multiple-choice, checkboxes, short answers, and long answers were used in the survey, which addressed questions about name, age, where they live, design feedback, and desired features. Bangladeshi people with smartphones and a minimum idea of how to run an app were the targeted respondents for the survey evaluation. Later on, we filled out the questionnaire on Google Forms using the data collected from patients. The majority of the participants were in the age range of 19 and 30, who answered the survey questions.

Patients can directly communicate with doctors, and choose a hospital of their desire, and emergency ambulance services were among the suggested features. "Liver Cancer Prevention" and "Symptoms and Medication" were found to be the most helpful features, although "Reminders of Medication" and "Reminders of Appointments" were suggested for improvement. Therefore, most of the respondents said they would use the app and recommend it to others, which shows a willingness to use every feature of the app. In order to understand better and utilize the features, participants showed a desire for a clickable prototype.

The results emphasized the necessity of a Bangla language mHealth app to break down barriers to communication and attract more Bangladeshi people suffering from liver cancer. Important aspects such as "A registry form with an option to upload medical files" and "Education on Liver Cancer" features were appreciated for their specialization and support, while the "Reminders of Appointment", and "Reminder of Medications" features were important for tracking appointments and medication. From the feedback, it was found that engaging people and promoting regular usage of the mHealth app requires an intuitive design. Most of the respondents to the survey said that they had never used an mHealth app before, and some of them said they do not have a smartphone but are considering buying one. But overall, many of them were interested in using the app in the future and recommended it to others.

The low-fidelity prototype was well accepted and provided useful information for future development of the app, which shows a willingness to use the app. The feedback indicates that the app has a great deal of promise for people in preventing and guiding them about the disease; yet, more improvements are needed to enhance the user experience and ensure that the features work properly. The continuous user feedback process will be used to ensure that the app meets user needs and preferences before developing a high-fidelity prototype. This approach ensures that the app will be customized to the particular needs of Bangladeshi people, improving the efficiency and accessibility of managing liver cancer.

3.7 High-Fidelity Prototype

The transformation from a low-fidelity to a high-fidelity prototype marks a crucial advancement in the development of the app, specifically for Bangladeshi people who are potentially or currently suffering from liver cancer. The low-fidelity prototype went through evaluation incorporating 53 participants, with an average age of 43.3 years. Survey feedback from this phase marked a strong appreciation for all features, particularly the "Liver Cancer Prevention" and "Symptoms and Medication" features. The majority showed interest in future use and willingness to recommend the app to others, focusing on the need for a more interactive prototype.

After receiving positive feedback about the low-fidelity prototype, a high-fidelity prototype was thoroughly developed using Figma, ensuring the entire interface was in Bangla for user accessibility. The design prioritized simplicity and user-friendliness, applying a soothing light pink theme to reduce eye strain. Visual demonstrations are shown through the realistic design for the progress of the development from simple sketches to interactive simulations, focusing on important features from the low-fidelity prototype to the high-fidelity prototype.

The transformation to a high-fidelity prototype signifies a major next step toward building a refined, fully functional app. By using user feedback and the advanced design tool Figma, the authors have created a well-organized and efficient prototype. The continuous method of development ensures that the app has prototypes which are user-friendly,

providing a solution that satisfies the particular requirements of the target audience. It shows the significance of user-oriented design, language accessibility, and interactive features that aim to empower Bangladeshi people to manage liver cancer effectively.

4 Prototype and Its Features

4.1 Prototype

Prototyping is a crucial part of any product development and is followed by most entities if not all that develop any type of product, in particular, companies. An early version of a product is known as a prototype, and a prototype is essentially used to test the design, functionality, and user experience (UX). There are many different types of prototypes, such as low-fidelity prototypes (simple wireframes, drawings, or diagrams that focus on flow and structure). Design and development of the low-fidelity prototype have been shown in the previous chapter of this work, outlining the full process. After a low-fidelity prototype has been developed, it is used as a research and development tool to improve the UI and UX of the app. It is also used as a reference for the development of a high-fidelity prototype. The transformation of a prototype from low-fidelity to high-fidelity is shown in Fig. 6. Prototyping helps create a development process that is both productive and user-centered by collecting feedback, addressing issues, and iteratively improving designs.

Figure 6: Transformation from low-fidelity prototype to high-fidelity prototype

4.2 Home Page

The user will be greeted with a home or landing page that will highlight the benefits of the 'LiverCare Registry' app, as shown in Fig. 7. At the top are the logo and the name of the app 'LiverCare Registry'. The following are the descriptions of the functions of the

app. As mentioned earlier, the app will be in the Bangla language. Users will be able to log in to their accounts by clicking on the “Get Started” button to go to the “Sign Up” page.

Figure 7: Home Page

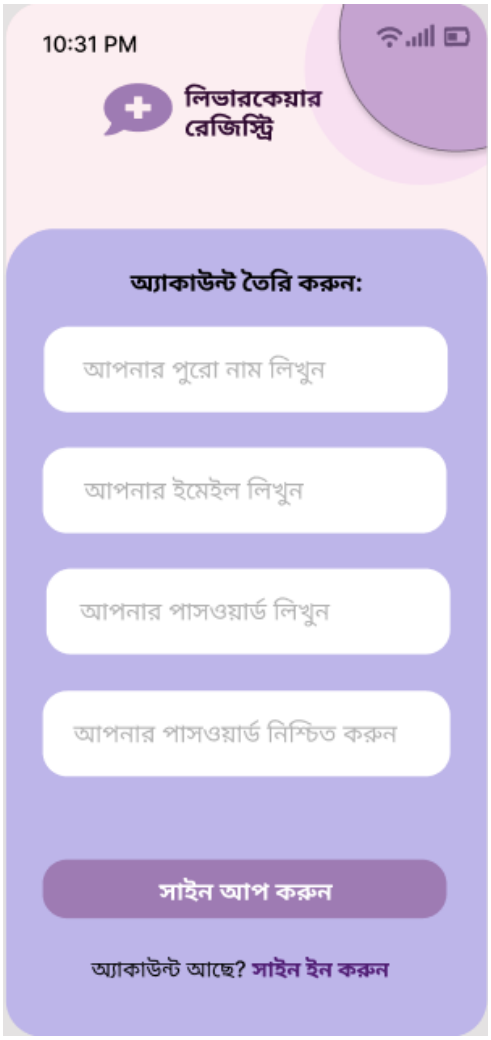

Figure 8: Sign Up

4.3 Sign Up

In Fig. 8, it can be seen that there is a form with inputs to enter full name, email, password, and confirm password to register to open an account in the app. After filling up the form the user clicks the “Sign Up” button to open the account. Or, if the user already has an account, then the user can simply click the “Sign In” button to log in.

4.4 Sign In

As depicted in Fig. 9, the sign-in page provides a secure and user-friendly interface for accessing the ‘LiverCare Registry’ app. Users will be prompted to enter input the email and password in clearly defined input fields. The page features a clean, intuitive design consistent with the app’s overall user experience. A prominent “Sign In” button allows users to access their personalized account after entering their credentials. The login page

also includes robust security measures to protect user data and ensure a safe, confidential experience for users using the 'LiverCare Registry' app.

Figure 9: Sign In

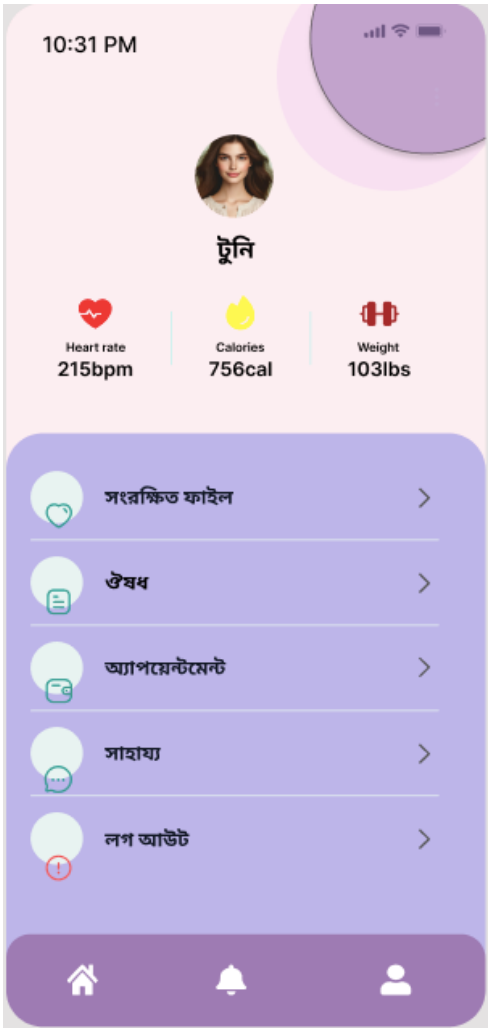

Figure 10: Profile

4.5 Profile

As illustrated in Fig. 10, a scene of how the profile of the user might look is shown. This is when the user clicks the "Profile" icon at the bottom of the page (the last icon after the "Bell" icon). In this scene at first heart rate, calories, and weight can be seen. These are recorded by the user itself. The user can measure all of these and then keep a record of these here. After this, here comes a list of options as follows. The first option is to save medical files. The second and third options are for keeping a record and reminder for medication and for reminding of the appointment with the doctor respectively. When the reminder is set in this option, it will come as a notification that can be heard (as a sound will be played to draw the attention of the user), and seen when the "Bell" icon is clicked. The fourth option is to get help if the user is facing any kind of problem using the app. The last and final option is "Log Out" which when clicked a logout button pops up and the user can log out of the account just by clicking it. Additionally, at the bottom of the page, the first icon (on the left) that is visible is the "Dashboard" icon that looks like a house. Clicking this icon takes the user directly to the dashboard.

4.6 Dashboard

As illustrated in Fig. 11 and Fig. 12, this dashboard contains 8 buttons which are as follows: “Liver Cancer Registry”, “Education on Liver Cancer”, “Liver Cancer Prevention”, “Doctor”, “Hospital”, “Symptoms and Medication”, “Research”, and “Chatbox”. Each button takes the user to its corresponding page. In Fig. 11, at the bottom of the page, is a “Next Page” button to go to the next page of the dashboard. In addition, in Fig. 12, at the bottom of the page, is a “Previous Page” button if the user wishes to go back. The design of this page has been made instinctive intentionally so that the user can use the buttons without any hesitation.

Figure 11: Dashboard Page 1

Figure 12: Dashboard Page 2

4.7 Liver Cancer Registry

As displayed in Fig. 13, this is the main feature of the app that deals with the medical information of the user. The user can input their details according to the questions in the registration form. Then on the next page, as shown in Fig. 14, the user can upload medical files such as prescriptions, X-ray reports, etc., and then can submit the form by clicking on the “Submit” button after filling up the form. In addition, there are two buttons below: “Previous Page” and “Next Page” for going back and moving on to the

next page of the form, respectively. The details of the user will then go to the doctors for treatment/checkup purposes. Moreover, this data will be provided to the researchers, but anonymously using encryption, for research purposes. This is how the user's information is kept private and protected. The main motive of this feature is just to collect the medical data of the user and then treat the patient, or just conduct research based on the anonymous medical data.

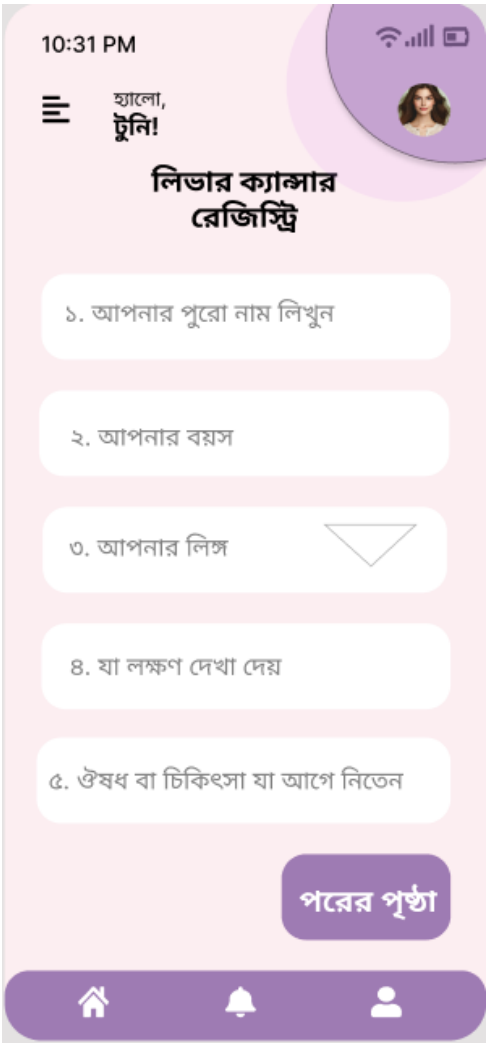

Figure 13: Liver Cancer Registry Page 1

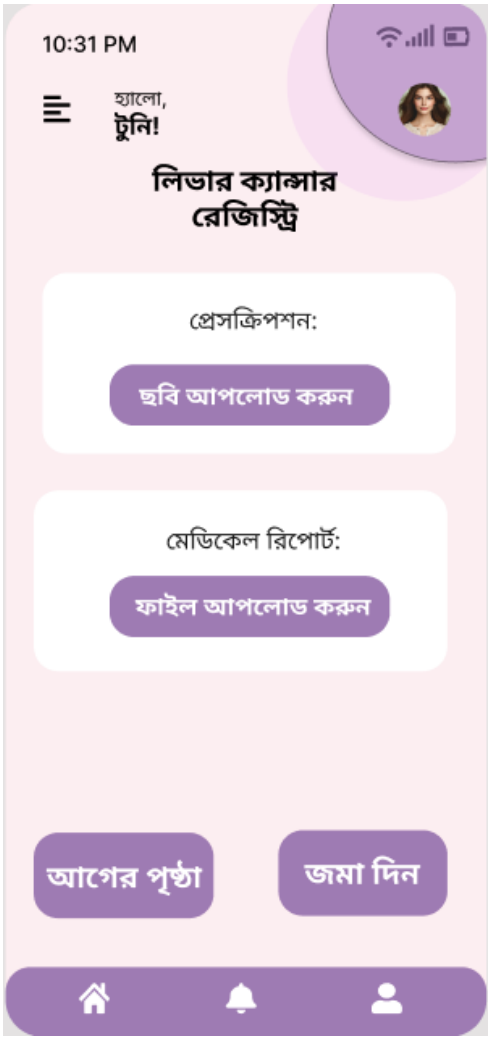

Figure 14: Liver Cancer Registry Page 2

4.8 Education on Liver Cancer

As shown in Fig. 16, the user can read detailed information about liver cancer, such as what it is, how people can become infected with it, and the factors that cause the disease. This will help users be very cautious, enabling them to take safety measures to prevent this disease. Also, if any new information is discovered, that will be updated here.

4.9 Liver Cancer Prevention

As depicted in Fig. 15, this shows the important measures that must be taken to prevent this disease from infecting people. On this page, safety measures such as vaccination

Figure 15: Liver Cancer Prevention

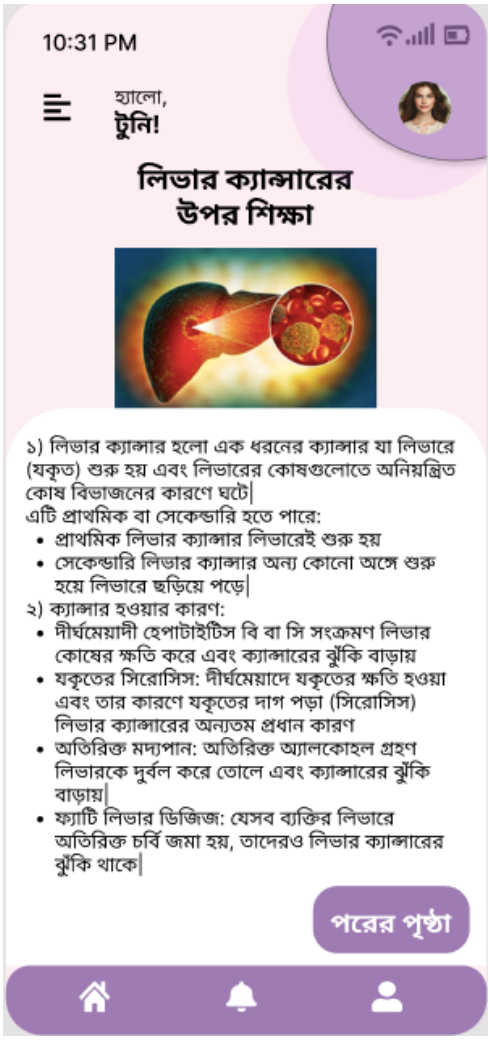

Figure 16: Education on Liver Cancer

for Hepatitis B, prevention of other diseases such as Hepatitis C, eating healthy food, exercising regularly, and getting a liver health checkup regularly are mentioned on this page.

4.10 Doctor

As shown in Fig. 17, the user can choose a doctor of their choice in the search bar. Also, below the search bar, there are options available from which the user can select a doctor by clicking on any of the options. After selecting, the user can then click the “Instant Appointment” button below. This will take the user to the next page as shown in Fig. 18 where an appointment can be fixed with the doctor at a reasonable time. Then the patient can communicate with the doctor through video call and get a checkup done. This is how the user can benefit from getting a thorough checkup done without having to waste time.

Figure 17: Doctor

Figure 18: Instant Appointment

4.11 Hospital

As can be seen in Fig. 19, this page provides a search bar for searching hospitals near the place where the user lives. This feature is for emergencies; for example, if a patient needs to be admitted to the hospital immediately, the user can just search or select from the options. Then the hospital details are displayed, such as contact and address. So, the user can immediately call an ambulance from the hospital and take the patient there as soon as possible.

4.12 Symptoms and Medication:

As depicted in Fig. 20, this contains all sorts of symptoms related to liver cancer. In addition, the medicines corresponding to the symptoms are listed accordingly. The user can go to this page and see if they are suffering from any of the symptoms. If so, then the medicines suggested here can be taken for temporary safety. Although the medicines here are prescribed by doctors, it would still be recommended that the user see a doctor for further consultation and diagnosis. A small disclaimer like this is given at the bottom of the page.

Figure 19: Hospital

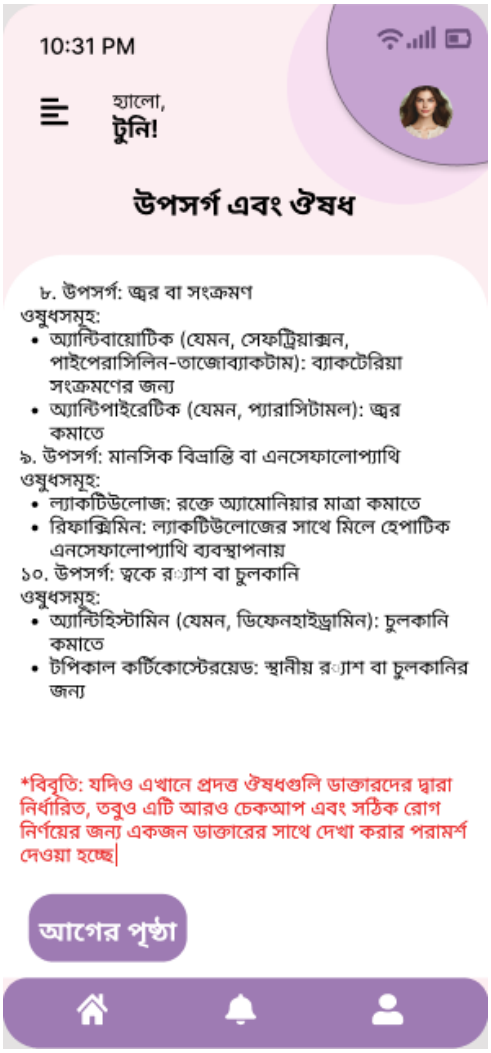

Figure 20: Symptoms and Medication

4.13 Research

As depicted in Fig. 21, this page shows the research on the survival rate of patients, results of treatment on patients currently and any new treatment that might be discovered in the future, and the genomic data of patients. Additionally, at the top of these three options, there is a form for joining the research team. If the user wishes to contribute to research, they can fill up the form and obtain permission to join.

4.14 Chatbox

As illustrated in Fig. 22, the user can connect and interact with other people affected by liver cancer or are about to get infected by it. This feature enables the user to share their experience with others and get advice and mental support from other people. This is how they can get inner peace which also helps a patient get better soon and maintain a healthy life.

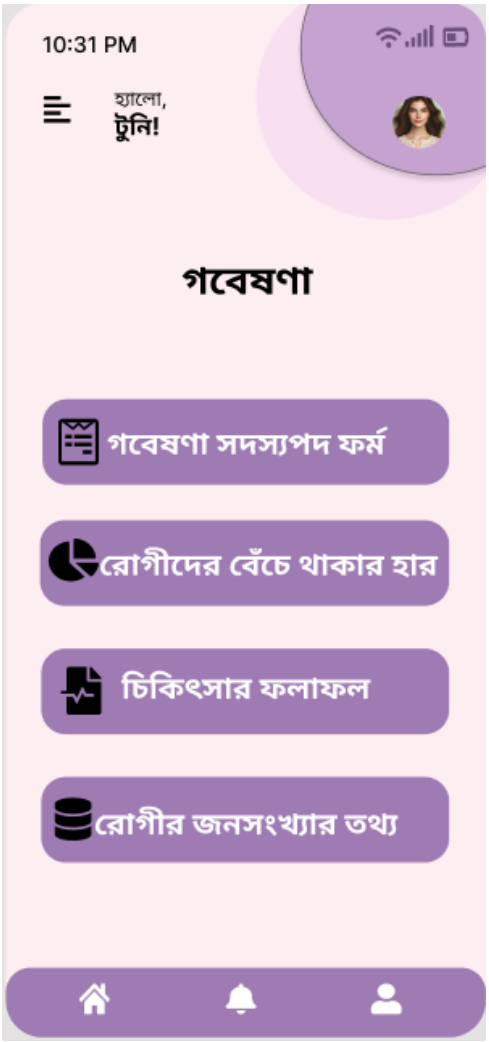

Figure 21: Research

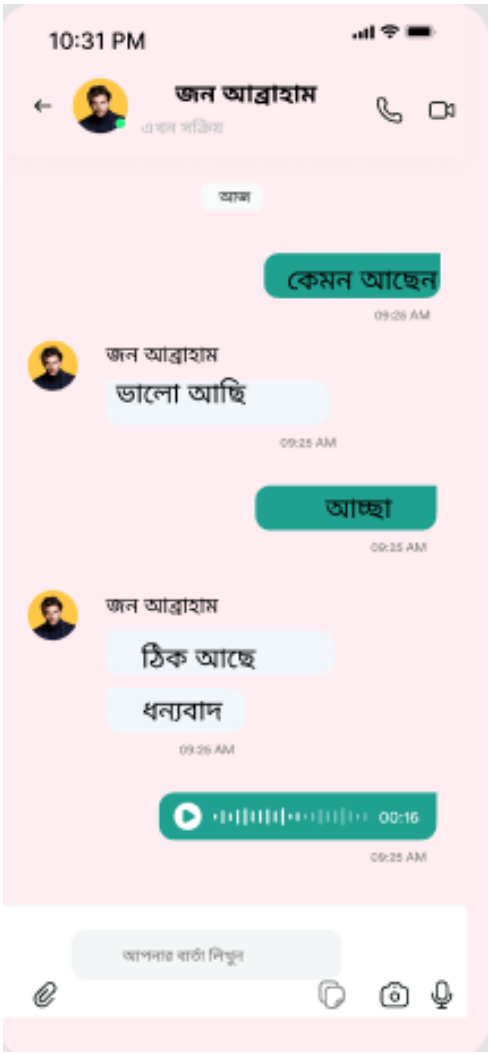

Figure 22: Chatbox

5 Results and Analysis

This chapter illustrates the results and their analysis. Throughout the research, we mainly conducted need-finding surveys to better comprehend user needs that were crucial to the development of the design. The need-finding survey evaluates the preliminary data collected from users to determine user requirements and preferences, providing a basic understanding of what users need. Based on the need-finding surveys, we evaluated both low-fidelity and high-fidelity prototypes. The low-fidelity evaluation addresses user feedback on the low-fidelity prototype, which is significant for determining key issues and areas for improvement before moving on to more refined iterations. Lastly, the high-fidelity prototype evaluates the findings from overall outcomes, along with optimizing the solutions based on user feedback and ensuring that the app successfully meets user expectations. A systematic analysis of the data collected from the surveys illuminates the primary insights that guided the design decision-making process.

5.1 Survey Design

This section illustrates the primary data collection to figure out the preferences and needs of the users. The data gathered from the 53 participants in this survey aided in the finalization of features intended for liver cancer patients and contributed to developing an overall understanding of what users truly need.

The age range of the participants who participated in the survey was found to be about 15.1%, of whom were aged 55 and above. Besides, about 3.8% of the participants were respectively from 31 to 45 years and 46 to 55 years. Moreover, 74.4% of the participants belonged to the age range of 19-30 years, as illustrated in Fig. 23. Most of the respondents, about 64%, ensured that they had deceased relatives in their family due to liver diseases, especially liver cancer, whereas 19% of them were affected by liver cancer and 17% of them have a family history of liver cancer, as shown in Fig. 24. It was seen that about 60% of the participants assured that they felt very comfortable discussing their health issues with healthcare providers, whereas 30% of them felt somewhat comfortable, and 10% of them felt uncomfortable. Furthermore, it was also found that 90% of the respondents had never participated in any national cancer registry, while only 8% of them had participated in a registry, and 2% of them were not sure about this.

A five-point Likert scale, containing “Strongly Agree” to “Strongly Disagree” as well as “Not Important” to “Very Important,” was used to collect our feedback on the low-fidelity prototype. The “Reminders of Appointment” feature was rated as “Strongly Agree” by 60.4% of participants, which represents extremely significant feedback, shown in Fig. 25. Meanwhile, 60.4% of the respondents evaluated the “Reminders of Medications” option as “Very Important”, whereas about 15% and 17% of people evaluated it as “Moderately Important” and “Neutral,” respectively, shown in Fig. 26. These evaluations are incredibly good. Additionally, we requested insightful opinions from the participants regarding the features that would inspire them to utilize our app. We discovered that, at about

81.1%, they preferred the "Liver Cancer Prevention" feature the most. Then, almost 73.6% of them preferred the "Symptoms and Medications" feature. Of the participants, 69.8% expressed satisfaction with the "Education on Liver Cancer" feature of our app. On the other hand, participants enjoyed the "Communication with Doctors" features approximately 67.9%, which is almost similar to the "Education on Liver Cancer". About 62.3% of participants enjoyed the "Choosing Hospitals" feature, while approximately 60.4% and 58.5% of participants appreciated the "A registry form with an option for uploading medical files" and "Reminder of Medications" features, respectively. Additionally, we discovered that only roughly 52.8% of participants enjoyed the "Chatbox" features. Finally, just roughly 1.9% of those who participated liked "Research", shown in Fig. 27. Most of the participants, about 88% , considered the liver cancer national registry as very important for the national healthcare, as illustrated in Fig. 28. Overall, every participant expressed a willingness to use the app and regarded the features of the high-fidelity prototype as extremely beneficial. Of the participants, approximately 92.4% are interested and willing to utilize our app, while 3.8% of the participants are not sure if they will use our app, and the remaining 3.8% are not willing to use the app, as shown in Fig. 29.

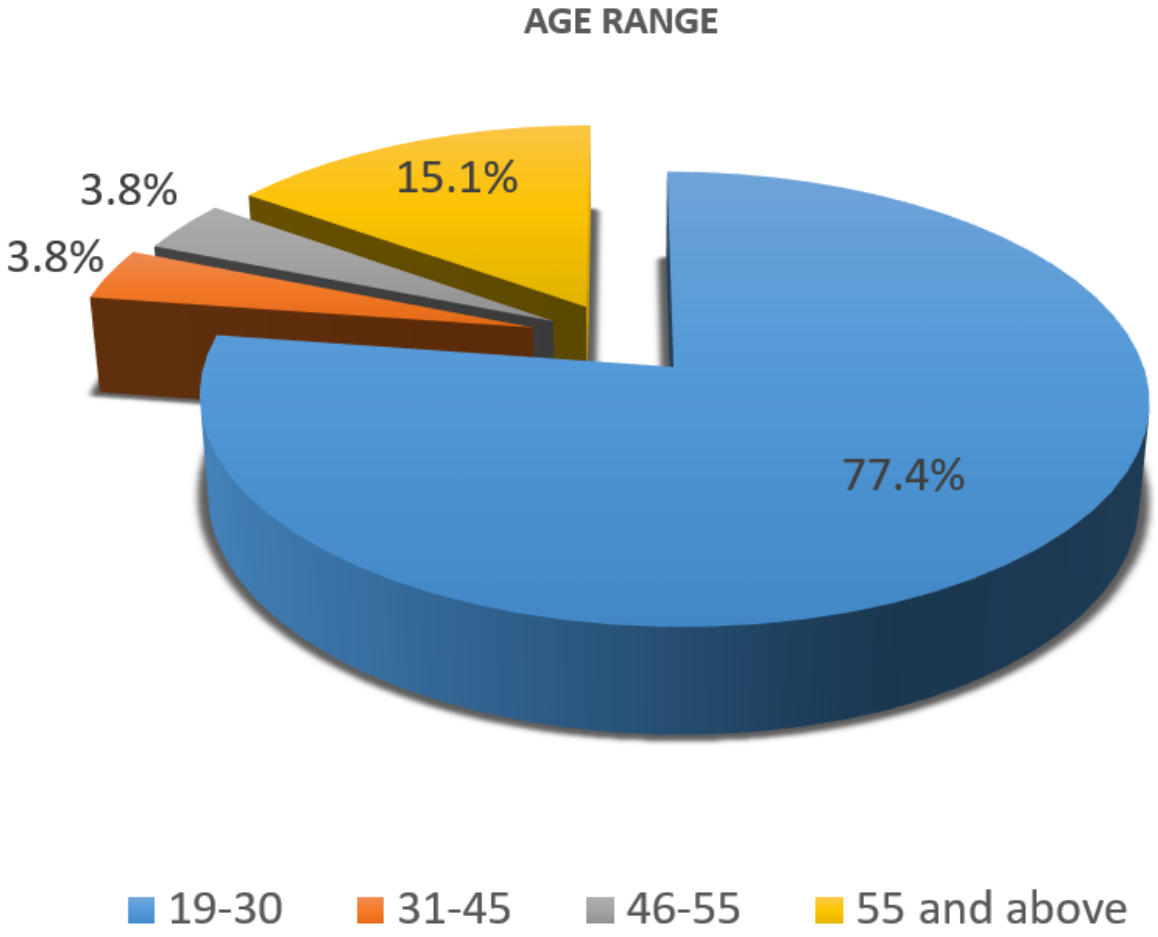

Figure 23: Percentage of the ranges of the ages of the participants

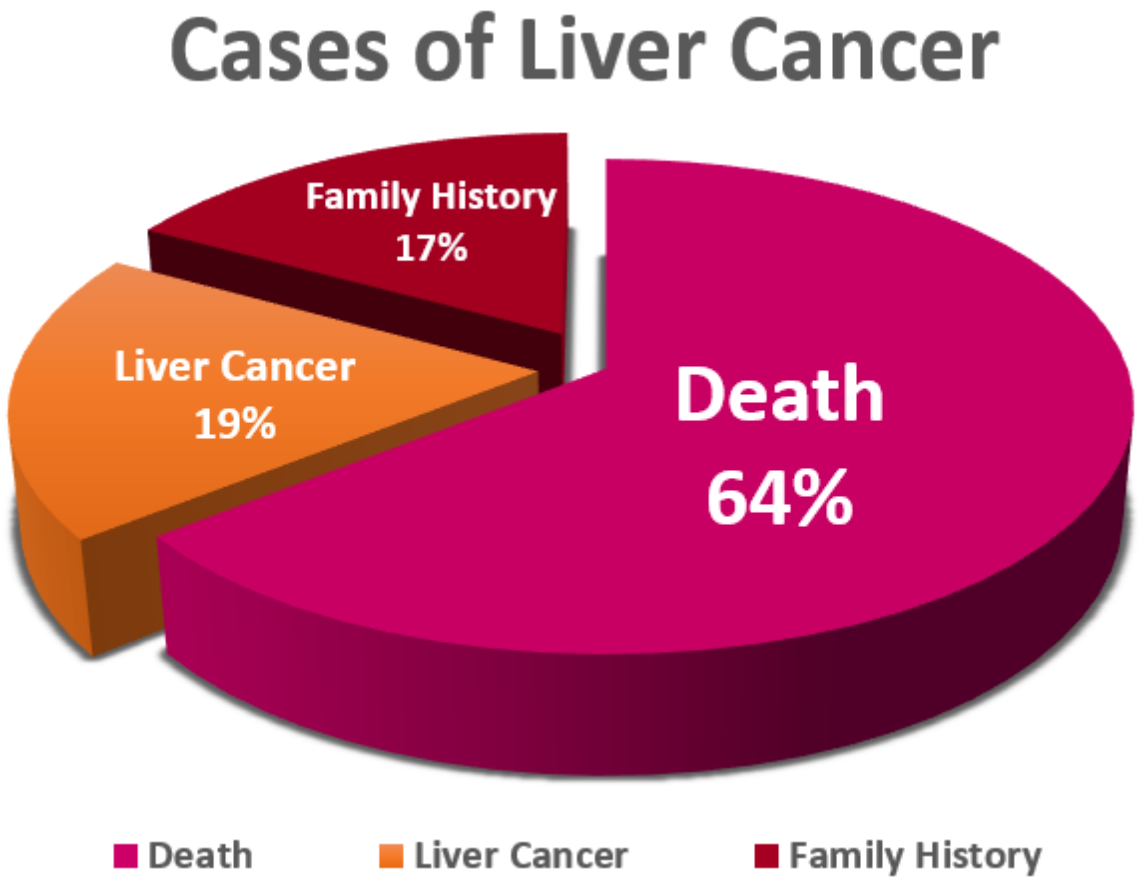

Figure 24: Percentage of liver cancer patients, a family history of surviving cancer patients, and deaths based on the feedback from the participants

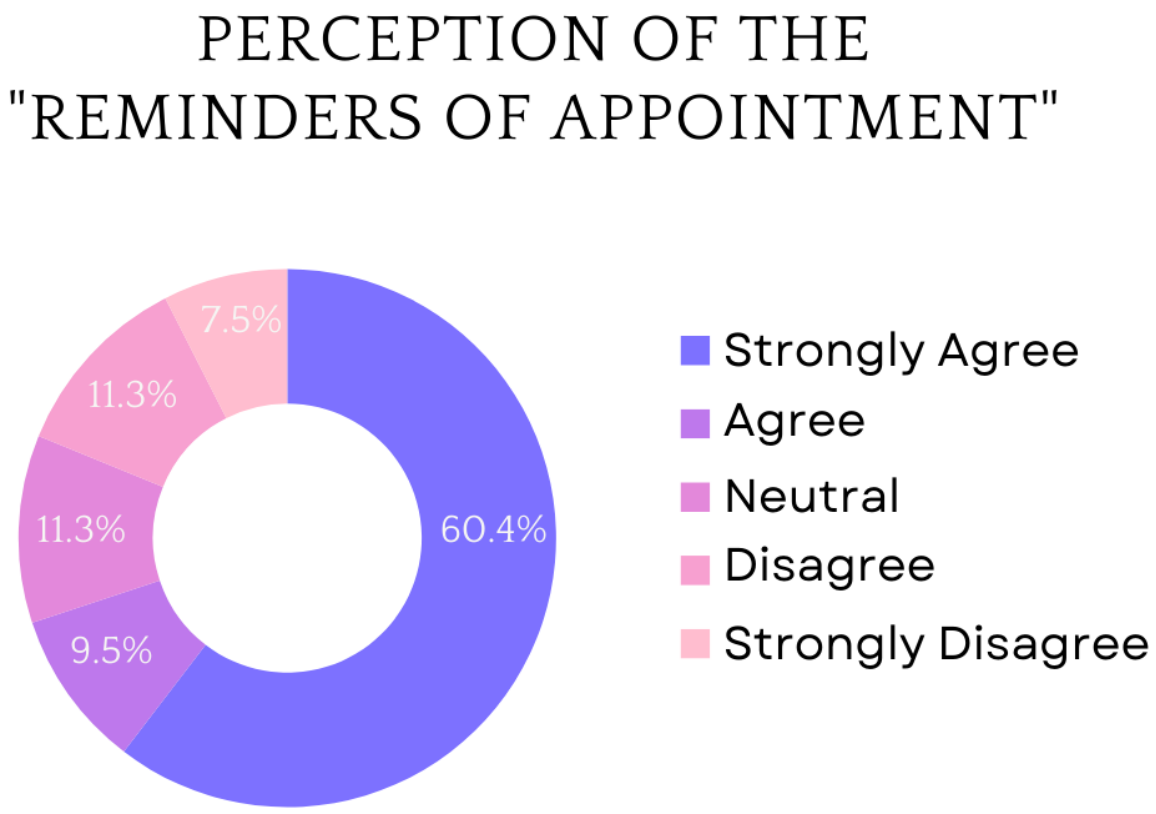

Figure 25: A pie chart showing the participants' perception of the "Reminders of Appointment" feature

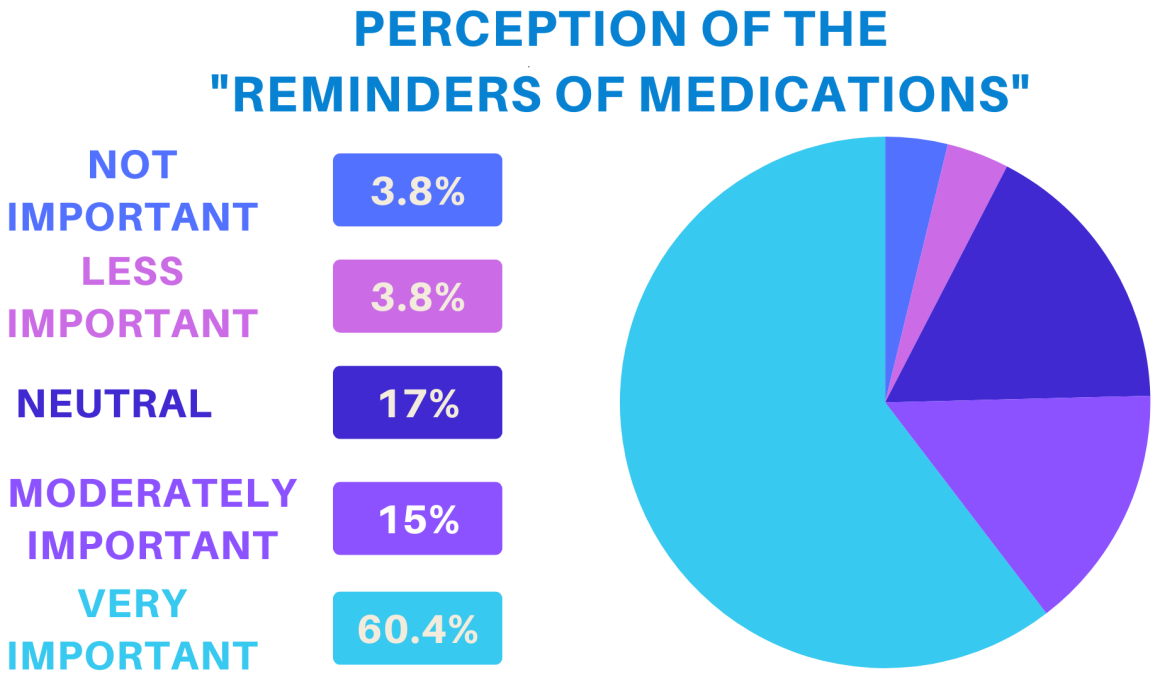

Figure 26: A chart showing the participants' perception of the "Reminders of Medication" feature

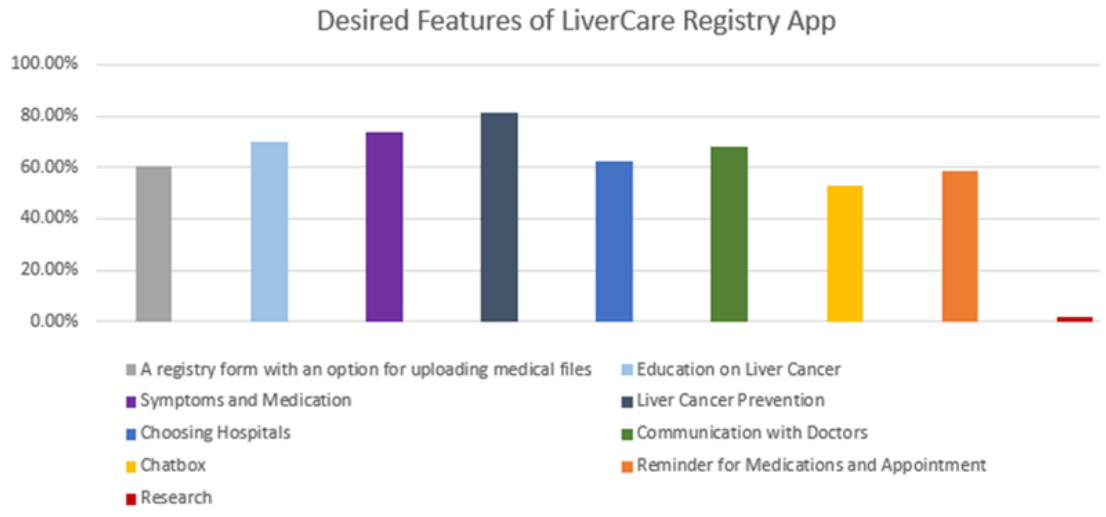

Figure 27: A bar graph showing the desired features of the 'LiverCare Registry' app that the participants liked the most

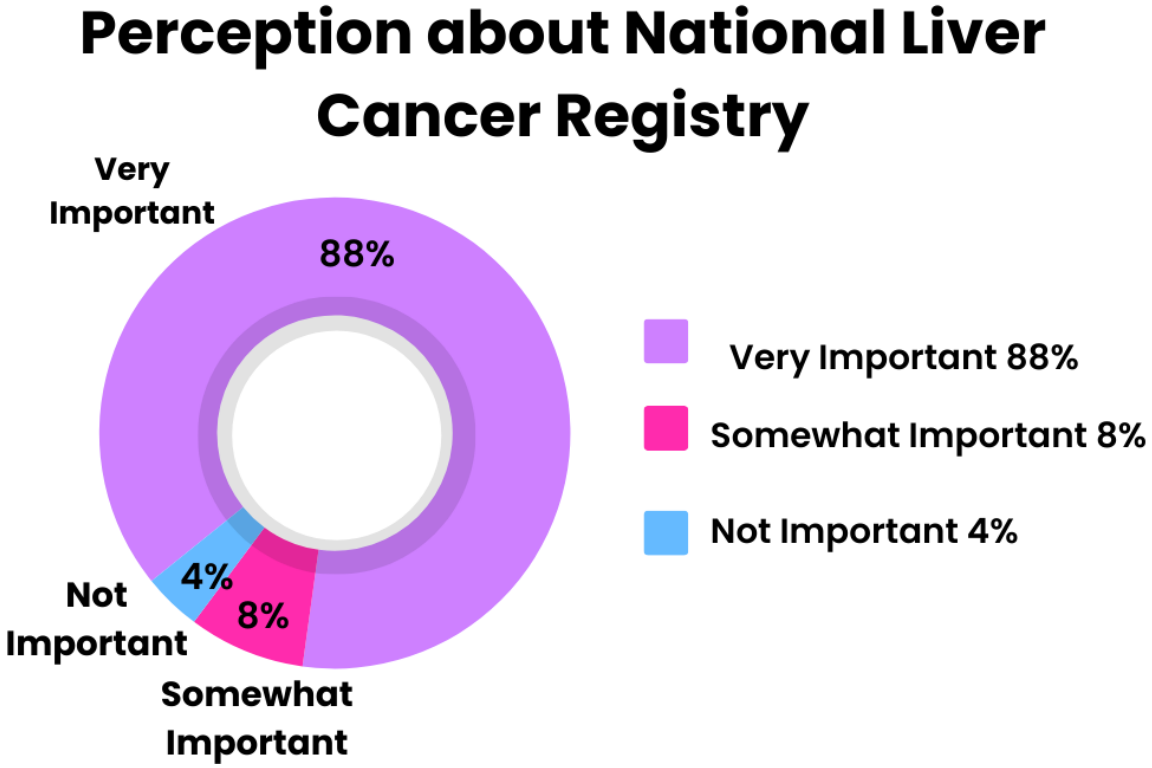

Figure 28: A chart showing the participants' perception of the National Liver Cancer Registry

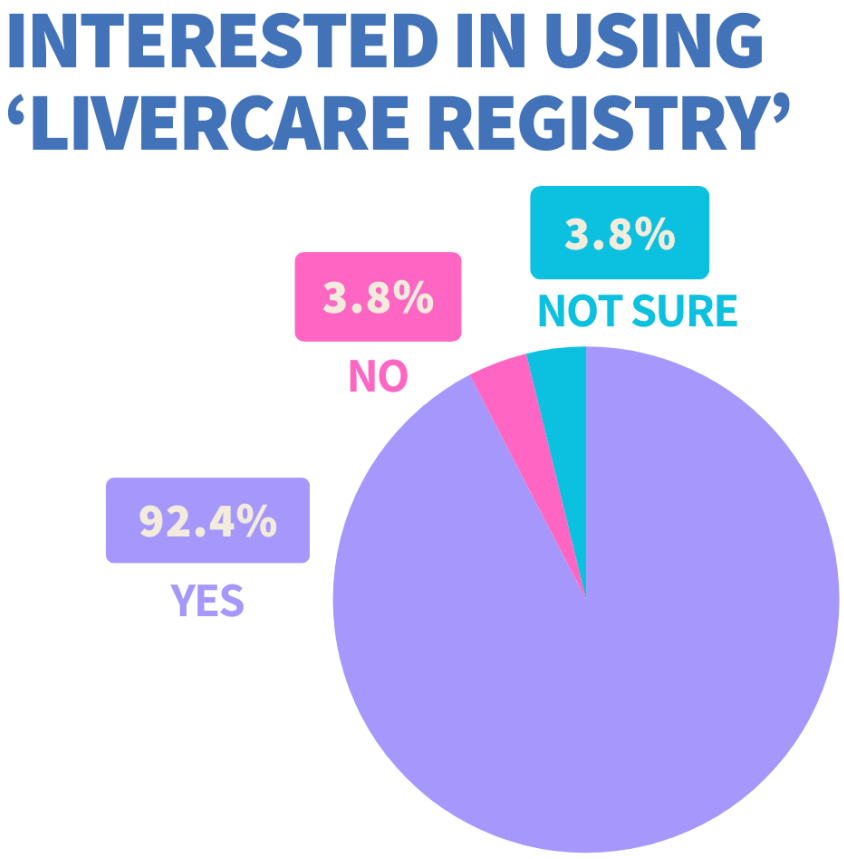

Figure 29: A pie chart showing the willingness to use the 'LiverCare Registry' app among the participants

6 Discussion

In this research, In order to determine and consolidate features for the 'LiverCare Registry', we have conducted an extensive evaluation of existing studies by implementing the UCD methodology. We encountered several obstacles during this entire procedure, which had an enormous impact on the findings of the research. All of these limitations and challenges significantly influenced the subsequent outcomes of our research. Nevertheless, despite all of these obstacles, we accomplished significant achievements in a variety of critical areas, which allowed us to deal with the primary objectives of the research successfully.

To provide a clearer explanation of the results of our research, we will initially go through the most significant figures and trends we observed, presenting contextual information along with interpretations to assist in clarifying their meanings easily. The certain constraints that might have hampered the potential impact of our outcomes will then be discussed. These restrictions include constraints on collecting information, obstacles to communicating in other languages, an abundance of internet access, along potential biases that perhaps hindered the outcome of the research.

Additionally, we also intend to look at the hurdles encountered during the entire process of the research, including technological issues, an inadequate supply of resources, and unanticipated circumstances that might have impacted the outcomes of the study.

Nevertheless, despite all these constraints and challenges, our research yields significant insights. Notwithstanding these potential drawbacks, the outcomes of the research encouraged plenty of additional research studies, along with underscoring the significance of resolving the substantial problems identified in the current study.

We added the "Research" option, where all relevant data regarding liver cancer will be collected from patients provided by only healthcare representatives. Community and educational features include a "Chatbox" for communicating with other patients who have gone through liver cancer, "Education on Liver Cancer" and "Liver Cancer Prevention" to enhance liver cancer-related knowledge and relevant resources. The prototype was designed specifically for Bangladeshi users in Bangla. According to the questionnaire, "Liver Cancer Prevention" is the most liked feature, followed by "Symptoms and Medication." Participants liked both features "Education on Liver Cancer" and "Communication with Doctors" almost equally, which ranked third. The "A registry form with an option for uploading medical files" and the "Reminder of Medications" features were similarly liked by the participants who considered them crucial. The "Choosing Hospitals" feature was liked by the participants as they thought it was unique and essential for the patients. These findings confirm the necessity and effectiveness of providing educational resources and tools for observing the condition of liver cancer on one's own, as evidenced by their positive reception among the target user group.

The features in our prototype were specially designed to address the requirements of liver cancer patients in Bangladesh and regulate the country's liver cancer national registry. The outcomes of the survey demonstrate a considerable interest in and willingness to embrace and suggest the app, despite several issues with user compliance and data cred-

ibility. More specifically, if future development cycles can successfully resolve highlighted issues among these different participants, there are potential beneficial consequences for the management of the liver cancer national registry with this app.

We conducted a comprehensive review of scientific papers to identify and gather features for the 'LiverCare Registry' app using the UCD process. It consists of many features such as "Liver Cancer Manager" app that has features like education on liver cancer, liver cancer prevention, communicating with doctors, reminders for medications and appointments, and a list of medications. Besides, the "LiverWell" app is quite similar to the 'LiverCare Registry' app, having common features related to education on liver cancer, liver cancer prevention, communicating with doctors, reminders for medications and appointments, a list of medications, and uploading medical reports. However, this app does not have an option for choosing a preferred hospital and utilizing clinical data for research purposes, which is included in our app. The "My Liver Care" app has some features that are already included in our app, whereas some features are missing. The "Liver Health" app is not similar to our 'LiverCare Registry' app, as our app has some significant features that are not provided in that app. Some other apps were also found from research papers during SLR and those features have been compared with the features of our potential app.

Based on our knowledge and research, we have found no app geared toward Bangladeshi liver cancer patients along with a liver cancer national registry. However, the existing apps have become the comprehensive blueprints of our process. These apps have provided the prime insights and directions that have led to the current development of the 'LiverCare Registry' app to meet the needs of our target group effectively.

By doing this, an all-in-one solution that is user-friendly and culturally relevant would be developed, adhering to the fundamental elements found in these very applications. In this respect, the 'LiverCare Registry' addresses specific obstacles confronting liver cancer patients in Bangladesh, thereby enhancing their overall well-being and health.

Although many features could be included in subsequent versions, the 'LiverCare Registry' app's existing features are already beneficial to patients with liver cancer. The features that are currently available provide some crucial forms of assistance that would strengthen the health of the concerned patients.

6.1 Limitations and Challenges

6.1.1 Limited Participants

To adequately acknowledge the limitations of our research, it is absolutely necessary to take into account of the allowances made by our inclusion and exclusion criteria, which constrained our sample. According to the inclusion requirements, participants had to be able to operate a smartphone, have an internet connection, and be able to read in order to complete the surveys.

Although these selection criteria maximize the credibility and the potential, they additionally minimize its size and diversity. Because it is mandatory to have internet connectivity and the use of smartphones, we were able to eliminate participants who did not have this equipment, so the sample is mostly composed of participants who are adept at using technology. In the same way, the literacy requirements excluded people who would have contributed insightful feedback but were unable to take part because of obstacles to reading.

Evaluating the extent and relevance of our findings requires an awareness of these limitations. The constraints that are applied to the individual who participates in the

selection process may have an impact on the data obtained and the conclusions drawn from it. We anticipate that this acknowledgment will help put the outcomes of our study in perspective and suggest approaches to make future research more comprehensive.

6.1.2 Response Issue

As had already been disclosed, one of the primary obstacles in our research was the relatively small number of participants. We utilized the survey method to collect relevant data through in-person interviews rather than using online platforms. However, some patients were uninterested in disclosing any information at first. After understanding the whole situation as well as being assured that the provided data would be confidential, they disclosed their information willingly.

The questionnaire primarily consisted of Likert scale questions, multiple-choice questions, and checkboxes, along with a few short-answer questions as well as long-answer questions. Even though these formats work well for evaluating responses and observing patterns, they are inadequate in capturing the complicated rationality that underlies the decisions of the participants in their unique circumstances. This limitation led to it being more complicated for us to comprehend the explanations behind their responses.

Our understanding of the motivations and experiences of participants is limited by the lack of a shortage of participants. As a result, we are unable to perform more in-depth studies and produce more comprehensive results. Open-ended survey questions and other techniques that enable more thorough and contextualized responses would be highly advantageous for future research. The use of this approach would improve the standard of the outcomes and present a deeper comprehension of the viewpoints of the participants.

6.1.3 Language Barrier

The whole app was created in Bangla. In contrast, some prospective users might find the app difficult to use because they are unfamiliar with this language. With enormous regional influences and variances across several cultural and geographic regions, Bangladesh represents a linguistically diversified landscape. Although these regional languages and dialects are crucial for communication, Bangladeshi speakers may have substantial difficulties when attempting to fully utilize the program.

Given the diversity of spoken languages in Bangladesh, people who speak various regional languages or dialects as their primary language might not be able to use a Bangla app. This limitation might hinder the app's functionality and user base, particularly in places where Bengali is not the primary language. Furthermore, although Bangla speakers communicate in multiple dialects, the app might create confusion or make navigation complicated if it ignores the unique dialectal nuances of users whose native language is Bengali.

6.1.4 Lack of Rural Participants

Our study mainly consisted of individuals from urban regions with secure access to the Internet and smartphone devices. It is crucial to keep in mind that the majority of the people in Bangladesh live in rural areas, where their lifestyle differs drastically from that of those who reside in cities. These disparities include variances in daily routines, socioeconomic circumstances, as well as having access to technology.

There are several obstacles to overcome when interviewing people from remote regions, such as travel-related logistical difficulties, fostering community trust, and making sure

interviewees comprehend and feel at ease with the procedure. Due to limited resources, our study faced constraints in accessing rural participants.

The lack of rural participants in our study highlights questions about how representative the experiences and viewpoints of Bangladesh's more diverse population are. Future research must fill this gap. Future studies may improve the validity of the outcomes of the research by involving rural individuals, who would provide a more thorough picture of various requirements and lifestyles seen throughout Bangladesh.

6.1.5 Accurate Data Input

The efficacy of the application is dependent on users' entering data accurately and on time. When users fail to submit data promptly, the efficacy of the application is jeopardized. The effectiveness of the app is significantly hampered by this problem with user compliance and data accuracy. For the app to produce helpful recommendations, timely and accurate input is required. However, users frequently find it difficult to precisely and consistently report their activities due to the demands of daily life, especially for individuals with hectic schedules.

In order to improve user compliance and the accuracy and usefulness of the app's recommendations, these issues must be resolved. By adding features that aid users in more effectively handling their data, these problems may be reduced, and the app's ability to provide reliable and beneficial advice may be guaranteed.

7 Conclusion and Future Work

This project set out to create a mobile health app called the 'LiverCare Registry', aimed at supporting liver cancer patients in Bangladesh. The app was developed with local needs in mind, using the Bangla language and a user-focused approach to tackle some of the key challenges in liver cancer care, such as limited data, low public awareness, and difficulties accessing proper treatment.

The response from users was very encouraging. More than 92% of those who tried it expressed a strong interest in using the app. They found features like medication and appointment reminders, educational materials, tools for prevention, and doctor communication especially helpful. While there are still limitations like limited smartphone access and low digital literacy, the app was purposefully built to be as simple and accessible as possible, even for people who aren't used to using such technology.

Though it's still in the prototype phase, early feedback shows the app has real potential to help both patients and healthcare workers. Looking ahead, we're planning to integrate machine learning to make the app smarter. This could allow it to offer personalized health tips, verify medical records, and provide reliable, anonymous data to support medical research. We're also exploring ways to roll out the app in other languages so it can help people in different countries, too.

To sum it up, the 'LiverCare Registry' could be a game changer not only for individual patients managing their health but also as part of a wider effort to improve cancer prevention, treatment, and research across the country and potentially beyond.

The 'LiverCare Registry' app provides access to healthcare along with other beneficial features for patients with liver cancer in Bangladesh. Features including symptom tracking, appointment management, risk assessment, etc., will be added through further research and development. Moreover, AI-based early detection will help in analyzing the user's data, lab test results, and imaging reports that will assist in diagnosing liver cancer early. The incorporation of AI-driven evaluation will provide better health insights and recommendations, and will ensure that users maintain their health management schedules, features of games related to health will be updated.

In order to help users with hearing difficulty, future development will provide audiobooks of their healthcare reports. In the future, more languages along Bangla will be added to the app to offer service internationally and to indigenous people Usability measurement scales like the System Usability Scale (SUS) and Mobile Application Rating Scale (MARS) will be used to evaluate the fully functional app. With a focus on effectiveness, these scales will offer thorough quantitative and qualitative feedback on the app's design.

This app will expand to accept genetic and biomarker data for personalized risk analysis, also a clinical matching system will be featured to notify the eligible users about their medical profile. Family members of the patient can also monitor their health records through this app. This app will run a monthly campaign to create awareness about liver cancer among the people of Bangladesh. This will help in assisting the management of liver cancer by allowing activity tracking and counseled guidance. Future research may

significantly help to improve the use and create an impact among the people about liver cancer regarding managing the disease. These advancements will enhance and promote healthy lifestyles and overall health outcomes for the people of Bangladesh. To achieve our goal of offering better healthcare benefits to patients, the app will feature machine learning to improve data analysis, prediction, and decision-making based on patient data. Machine learning will enhance the registry app by detecting patterns and predicting the outcomes of the disease, which will help doctors to make precise decisions.

A Appendix

A.1 Appendix A: Abbreviations

1. **App:** Application
2. **mHealth:** Mobile Health
3. **PRISMA:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses
4. **LMICs:** Low- and Middle-Income Countries
5. **HCI:** Human-Computer Interaction
6. **UI:** User Interfaces
7. **UX:** User Experience
8. **UCD:** User-Centered Design
9. **SLR:** Systematic Literature Review
10. **HBV:** Hepatitis B virus
11. **HCC:** Hepatocellular carcinoma
12. **HCV** Hepatitis C virus
13. **ISO:** International Organization for Standardization
14. **EPI:** Expanded Immunization Program
15. **GI:** Gastrointestinal
16. **HPB:** Hepato-pancreato-biliary
17. **ICT:** Information and Communication Technology
18. **iOS:** iPhone Operating System
19. **UGICR:** Upper Gastrointestinal Cancer Registry
20. **QoL** Quality of Life
21. **RQs:** Research Questions
22. **SUS:** System Usability Scale
23. **MARS:** Mobile Application Rating Scale

A.2 Appendix B: List of Key Publications from this Work

1. Nuha Najibah, Nahin Fatima, Md Alimuzzaman Farsi, Md Abu Sayed, Ashraful Islam, and M. Ashraful Amin, "Designing a Mobile App for a National Liver Cancer Registry in Bangladesh," *27th International Conference on Human-Computer Interaction (June 2025),* Springer.

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