Smart Sheba: An Investigation on the effectiveness of Integrating LLM enabled Chatbots and Using a User-Centred Design Strategy to Enhance User Experience of Older Adults

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Declaration

It is hereby declared that

1. The thesis submitted is our original work while completing the degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material accepted or submitted for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

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Abstract

Elderly users face physical, behavioural, and cognitive constraints as they age. As a considerable portion of the world's population comprises elderly people, the graphical user interfaces (GUI) of commercial technology applications should be simplified to mobilize this age bracket's soft skills and technology consumption. Yet, the comfort of this age range is often overlooked while designing smart technology interfaces. Several studies indicate potential design strategies for different technologies.
The paper, subsequently, tests an e-health application designed using UCD strategies, consisting of chatbots using AI, to meet the cognitive needs of the elderly and to make their interactions with the application easy, intuitive, and comfortable. The paper introduces the use of AI, specifically the Large Language Model (LLM) of the Natural Language Processing (NLP) system, to create a friendly and human-like chatbot that will assist elderly individuals or their caretakers in determining the nature of the illness, suggest the type of specialist to refer to, and list down hospitals that provide the required care. This research aims to build an e-health application to study the design methodologies that might assist elderly people with intuitive instructions across all interfaces, explore new possibilities by incorporating User-Centric Designs (UCD) and Artificial Intelligence (AI) in the application, and propose findings to conclude a model design for conventional applications to exhibit an elderly-friendly framework.
After testing out this application on elderly people (N = 18), the findings from the data gathered suggest design strategies that can be implemented or have further research done on them to empower the elderly population to use applications on smartphones and other smart devices independently. To conclude, this research seeks to suggest ways to optimize smartphones and smart devices for the cognitive needs of the elderly. This research will address the specific needs and preferences of elderly users and assist them with medical trepidations. By addressing this gap in design, this research seeks to effectively design e-health interfaces that can be altered and used in other such interface designs to make them elderly-friendly.

Keywords: HCI, elderly, eHealth, UI design, UCD, LLM

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Chapter 1

Introduction

In the rapidly digitizing world, all modern technology interfaces are designed using user-centric designs (UCD) that adhere to the principles of human-computer interaction (HCI). Although UCDs are made to meet the needs of any end user, the graphical user interfaces (GUI) of common smart technologies are largely hostile towards the elderly age bracket (people above 55 years of age). As people age, many require medical assistance quite often. Hence, this paper focuses on building an e-health application that will be elderly-friendly and will specialize in assisting healthcare specialist selection. The crux of the paper is to assess the feasibility and efficacy of leveraging UCDs while building an e-health application to tailor elderly-friendly GUI designs that can be implemented across other smart devices or applications to make them elderly-friendly. Furthermore, the paper will test the use of an assistant chatbot for seamless and human-like customer care service using a Large Language Model (LLM), from a Natural Language Processing (NLP) system built on Artificial Intelligence (AI), to study the effectiveness of using virtual chatbots to generate elderly-friendly prompts and applications.

Challenges

Elderly people make up a significant world population, with 10% of the world population being over 65 years of age in 2022 alone [80]. However, existing user interface designs are seen as intimidating by elderly citizens. Studies [36] suggest conducting more research on the older demographic to finalize design strategies for this age group.

Addressing cognitive issues of the elderly [31] is imperative when designing GUIs and requires more attention than any physical-related design challenge. Cognitive issues can be evaluated by determining the cognitive load of an elderly person, which is to ascertain the total load on the working memory of an individual while performing a task [2].

Tailoring UCD for Elderly-Friendly Applications

As cognitive load alone is inconclusive, the paper will consider other factors of gerontology such as degree of autonomy, visual impairment, critical thinking impediment, etc.[63]. With this in mind, the paper will deal with aspects of HCI to create design and assistance strategies for the elderly by exploring UCDs through an e-health

application. Tailoring UCDs, among other HCI principles, will elevate the degree of autonomy of an elderly individual by suggesting assistance strategies. In a GUI design for elderly users, the interface should be simple considering the physical and cognitive setbacks of their age [5]. Effective design patterns, including large buttons and clear text, visual aids and icons, inclusiveness, and accessibility, should be integrated into the end design of an e-health application.

LLM and Assistant Chatbox for Ease of Use for Elderly

Apart from testing interface designs for the elderly, the e-health application will be equipped with a chat screen with an assistant chatbox generated by the Large Language Model (LLM) retrieved from Open AI. The application named SmartSheba will have a chat screen, SmartDesk, where a chatbox, CentralCare, will be introduced to communicate with the elderly for ease of communication and comprehension of the application.

Consumer-grade LLMs are the latest developments in the field of technology. LLM, also known as Large Language Model, is a Natural Language Processing (NLP) system that is built on top of Artificial Intelligence (AI). The term 'large' refers to the size that the model can process. NLP is used to identify keywords in a sentence and understand a sentence structure which can be used for semantic analysis and emotion detection. NLP systems are now merged with AI to take them one step further to make generative pre-training transformers or GPT. GPT technology is further enhanced by training the system to adapt in a conversational manner such that the system predicts the next word from its base to a given set of inputs. These inputs are called prompts. Prompt feeding into the GPT structure enables the entire system to be called LLM. This trained model will be able to generate responses in a "human-like conversational manner." Consumer-graded LLMs are middleware protected; hence, the responses are aligned with societal norms. Open AI, with its innovation of a chat-like conversational LLM model, also referred to as Chat GPT has enabled the developers of applications to integrate this LLM into their systems. This paper will take a deep dive into the Open AI system and merge it with the personalized elderly-friendly application to test the efficiency, find out the scopes of optimal integration of such concepts, and assess the limitations of the model to further enhance the user-centered design approach in enabling autonomy for the less technologically sound elderly population.

After examining these details, this paper will conclude with a comprehensive outline of how to design products for the elderly population, with a focus on e-healthcare. Our main goal is to ultimately free the elderly from dependence on others in various degrees while they use smart devices such as smartphones. In doing so, the elderly population will be able to enjoy the benefits of modern technology without feeling left out.

1.1 Motivation

Over the past few decades, the population of elderly people has increased globally. The number of individuals over 65 in the world in 2022 was 771 million, or over

Figure 1.1: Interaction between elderly people and modern technology

a tenth of the total population. This segment is predicted to reach 16% in 2050 and, finally, 24% by 2100 since it has been developing steadily. This demographic change has also resulted in a significant increase in the need for medical care for elderly people. Advances in technology and e-health applications are working well to provide some promising solutions. However, it is uncertain how these applications will be accepted and adopted as this needs more research. Including limited familiarity with technology and potential health concerns, elderly people often face unique difficulties. Human-Computer Interaction (HCI) principles can be used to design eHealth applications that can hold immense potential to enrich the healthcare experience and overall well-being of an elderly individual. Many scholars design and research the advancement of HCI in the contemporary perspective of health and media to read human emotions better and design products using Human Activity Recognition (HAR) and other such models. So, here we aim to create an inclusive and accessible eHealth platform by using HCI and AI. With the help of HCI, several crucial factors can be demonstrated such as user-centered design, accessibility and inclusivity, ease of use, adaptability to cognitive changes, feedback and iteration, integration of assistive technologies, and many more when developing eHealth applications for the elderly people to support health management and boost overall user experience. On top of that, with the use of LLM and AI, elderly people will be able to interact with an easy-to-communicate chatbot to assist them in symptom evaluation and optimal suggestions of healthcare professionals. These practices can be studied further and implemented in other facets of user interface designs to foster elderly-friendly applications, making smart living accessible to a diverse age group.

1.2 Problem Statement

Information delivery is a key factor in the field of HCI. How will the information be delivered from the publisher to the consumer, this has always been a key concern from the perspective of a publisher. Here publishers can be businesses, individuals or any other party that is hosting or running any HCI service such as Websites, Applications or Chatbots. In the field of Healthcare, there are various methods by which the information is delivered. However, the most used digital method is Websites. The publisher here is the medical team or the hospitals and the consumer is the general people or the patients.

Figure 1.2: Lonely elderly man

Useful information such as availability of doctors, vaccination, emergency department, and ambulance information are fetched commonly through websites in the digital environment. Designers design websites for publishers in various methodologies to make the website not only appealing but also deliver information in the most efficient and precise way. The advent of web crawlers has made this journey much simpler. Where a simple Google search can find the precise information from a million lines of text in a particular website and redirect the consumer to that section precisely. However, technologies like Google Search come with a key limitation, where the information is not modified for the user. Instead, it acts as a mere director. This becomes problematic for the publisher and consumers.

Publishers face an issue now where they have to compete through millions of websites to rank in the search so that the process will be easier or if the consumer is precisely searching for the publisher then additional documents that are not important show up. The consumer thus gets lost in the complexity of this huge information. To solve this nowadays publishers are adding a chatbot to their websites or apps. However, these chatbots are limited as the user has to know precise terminology to get the information. From the perspective of the publisher, it is a nightmare, as the user query can be done in various ways and the method and tone of delivery setting from the perspective of the publisher in each case is almost impossible.

LLM's solve this problem by introducing GPT. Generative artificial intelligence generates precise content from its knowledge base to answer the user humanly. Technologies like Bing co-pilot solve this issue. However, co-pilot is limited by the same issue where it searches from millions of lines of texts of different publishers. If the user query is precise, it fetches information through the website. However, even this approach faces two key limitations

a. This existing latest system is not designed to be integrated into individual websites
b. Officials do not want to publish all information to a broadcast medium rather they might prefer information isolation depending on the consumer group in those cases the non-broadcast information has no way to reach the consumer.
c. This system requires knowledge of prompt engineering to make the responses precise as desired by the consumers.
d. Official has no control over how the system delivers the information.
e. Official are not able to integrate this technology inside their premises.
f. Consumers are not aware of precise prompt engineering.
g. Consumers do not get quality data without exact prompts.

However, this technology has immense potential to be only limited to a search facility. Open AI enables developers of applications and websites to include these systems in their websites and apps. Hence the publisher issue is solved.
However, this imposes new challenges on the horizon. In our case the hospital.

1.2.1 Issues for the Hospitals

Here in our research, the publisher is the hospital that delivers this information to the consumer to make them aware and enable autonomy in their decision-making and to make them enable to make informed steps. In the case of enabling LLM chatbots publishers face the following issues,

a. Lack of test data to make informed decisions in the context of Bangladesh in this genre.
b. Lack of research in this field in the context of Bangladesh to identify the limitations and the opportunities associated with it.

Along with the hospitals consumer groups also face various problems one of the prominent is a lack of information on prompt engineering. However, even though the young technology-curious group might discover the usage system in a short period the elderly group is being isolated from this technology. This creates a dependency problem for them along with the existing technology dependency problem. Here are the problems that the elderly are facing right now.

1.2.2 Issues for the Elderly

a.Dependency in making decisions for themselves due to lack of information in the Information Age.
b.Challenges in understanding complex layouts and prompt techniques.

A combination of these problems is a restriction on the path toward the digital autonomy of the elderly population and a reason for their increasing dependency on the younger generation for information, in the age of information.

In short, in the age of information, the elderly population is increasingly becoming dependent on the young generation for their information needs, especially for healthcare requirements, LLM-enabled chatbots offer a viable solution to this rising problem; however, the issue that might arise for hospitals is that the implementation of such technology is dependent of its performance matrix and a viable tested design strategy targeting this segment but in the context of Bangladesh, such research is very limited, which is a serious obstacle in the path of digital autonomy in healthcare for the elderly.

1.3 Research Objectives

The objective of this research is to develop a user-centered design tailored for the elderly, aiming to enhance their digital autonomy and support their medical needs. We aim to formulate a design strategy that empowers the elderly, fostering technological empowerment to meet their specific requirements.

Our first objective is to understand the perspective of the elderly in terms of the interface of the smartphone. Utilizing the perspective of the elderly as a foundation, we aim to construct an interface design that is friendly and accessible to this demographic. Additionally, our investigation seeks to understand how the elderly interact with the interface of applications and smartphones. Moreover, we aim to find out how much interface design affects elderly technology usage. Along with finding out the difficulties that the elderly need to face when using smartphones.

Moreover, our main objective is to find out the barriers that the elderly face while using smartphones and solve them. To come up with a design that would satisfy elderly cognitive needs. Another objective is to find out the smartphone usage of the elderly. It would help us design something that is user-friendly for the elderly. An additional goal is to explore the impact of the educational level of elderly individuals on their utilization of smartphones. This would contribute to seeing the pattern of education impact in terms of smartphone usage.

Our objective is to determine the preferred language of elderly individuals in Bangladesh concerning smartphone interfaces. Furthermore, to find out how language affects elderly smartphone usage. To find out what impact language can have in terms of educational qualifications. Similarly, we want to assess the usability and acceptance of many features of the eHealth app in terms of the elderly. Which would contribute to making a better eHealth app for the elderly.

Next, find out the performance and effectiveness of Open AI in generating responses or completing text in both the Bangla and English languages. In addition, it assesses OpenAI Assistant's capability to provide medical advice or suggestions for doctors. This would lead us to a better understanding of the future pattern of implementing and effectiveness of open AI in terms of the health sector.

We want to investigate the interaction patterns of the elderly with the Open AI chatbot and gather insights into their perceptions regarding its implementation in the eHealth sector. Another objective is to assess the impact of open AI in terms of doctor suggestions for the elderly.

1.3.1 Key Research Questions

The key research questions of our study are as follows:
RQ1. What type of design preferences meet the cognitive needs of an elderly individual when interacting with an application?

We have conducted field interviews with the elderly and the caregivers of the elderly to understand their cognitive barriers to the usage of mobile applications. In our initial data collection, we will deal with this part From the analyzed data, we will have a clear overview of the problems that the elderly face in their day-to-day life regarding the usage of mobile applications.

RQ2. How can user-centered design (UCD) strategies be employed to enhance their engagement with LLM-enabled e-healthcare technologies to promote digital autonomy?

Based on the initial data we have developed an application named smart-sheba and integrated LLM to solve the barriers. We tested the different versions of the application through various testing mechanisms to find out the optimal design and the limitations associated with each design strategy, By introducing an inclusive design strategy we will finish this paper by answering the last question.

1.4 Thesis Organization

After introducing the topic of this research which is to explore elderly-friendly interface designs through an eHealth application and to integrate AI into the application for assistance in technology navigation, the chapter discusses the issues of our proposed application model while outlining the key objectives of our research. The next section mentions significant related works in this field and gives an overview of some of the available models that work with eHealthcare. Chapter 3 addresses the technology and concepts used throughout our research that helped conclude our research objectives. Chapters 4 and 5 mention the various steps that went into extracting data and working with it. It mentions our proposed working model that was built using the feedback from some preliminary surveys and interviews. Chapter 6 discusses the results of our research and our unique contribution to this field along with the scope of future work. The paper concludes by recommending improvements and answering the research questions raised in the first section.

Chapter 2

Literature Review

The population of elderly people in this world is close to 700 - 800 million. The older people get, the more they tend to depend on medical and social care [39]. That is why HCI-based design for the elderly is a very crucial area of study. The study of HCI for the elderly first has to be looked at in a cultural context. Culture is a shaper of perception surrounding ageing. Is ageing a disability or an ability, shall one feel comfortable or subordinated is something that is shaped by culture [21]. Many papers highlighted the importance of factoring in the physiological, geographical, cultural and generational differences between the elderly and technology. Like paper by h, Yasuka and Mika [69] found that the Japanese showed resistance to digitizing their lifestyle and integrating IT into their life whereas the Dutch elderly embraced IT use in their daily life.

Several researches on the elderly have been conducted in pan-Asian countries. In China, a paper by Xiaolei Zhou and Wei Shen [24] focused on the difficulties of elderly people using a variety of computing devices. By comparing the movement time (MT) of two different age groups, they concluded that the elderly's MT is higher than younger people due to age. Moreover, Dongfang and Qiang [6] observed in China that technology-oriented devices aren't designed well for the elderly. So demand for applications that target the elderly is increasing.

2.1 The Role of HCI and Its Contribution In Elderly-Friendly Model Development

As HCI focuses on user-centric design principles to make user-friendly and effective technology interfaces, we believe focusing on this field for elderly-friendly interface study acknowledges the importance of integrating accessibility for all age groups. John Millar [79] describes HCI to be the key factor for integrating physiological, social, and computer science to improve the usability of a model, hence focusing on the design interface using HCI is the best platform to support our goal of forming a user-friendly interface for the elderly.

Previously, a study conducted by An Fan et al used statistical analysis to study elderly user behaviour and patterns while using mobile applications, in their study

they proposed a 'senior mode' user interface design for mobile applications [72]. In another study by Chengmin Zhou et al, they used a scenario-based design approach to examine the interaction performance of the elderly and what the elderly users need and focus on to develop an age-friendly smart home interaction design [71]. Additionally, Ortiz's [4] research on the elderly with Alzheimer's also reinforced the importance of consistency and visible aid as results of the research showed that patients were able to remember the emotions displayed by animated avatars. These papers reflect the importance of understanding the unique needs of the elderly which aligns with our goal of improving design patterns across all UIs to ensure seamless elderly-friendly interactions.

A review of 25 studies [65] on older adults interacting with codesign approaches to develop electronic healthcare tools (EHTs) found gaps in the learning model for the elderly. Their broad strategy encapsulated mostly collaborative approaches to analyse whether the elderly community unites in their mutual struggles of adapting electronic tools. Their results highlighted the importance of participation and mutual learning to optimise user experience. Even studies focusing on usability barriers of the elderly with Alzheimer's disease and related dementias (AD/ADRD) outlined cognition, speech and language as important impairments, among many others [54]. A study in Norway suggested designing healthcare processes should initiate integrating IT (web-based) technologies into its design [35].

To contextualize the benefit of tailored UI design for the elderly, there are several interface design studies available, such as the age-friendly smart home interaction design by Chengmin Zhou et al [71], the spatial awareness study of the older generation by Kuo-Ping Chang and Chien-Hsu Chen to propose an AR-based spatial visualization training system [19], and as such. HAR (Human Activity Recognition) using machine learning algorithms has also been used to analyze human actions even from smartphones, thus focusing on elderly-friendly use in this sector is emphasized in the study by Ahatsham Hayat, et al [66].

Gamification, the use of games in non-game contexts, has the potential to rehabilitate elderly people's health [29], hence drastically changing the perception of e-health among them. As IoT (Internet of Things) transforms various fields including healthcare, a study [74] points out the lack of gamification usage in emerging countries and its importance. With the rise in the use of mobile devices in the health sector, implementing applications like gamification provides prospects to keep track of one's health, however, the lack of functionality of the existing apps and services acts as the biggest barrier as of now [57].

2.2 Unique Cognitive Barriers Of This Age Quota

Older users are prone to an inferiority complex and "high-tech phobia" to get the in the flow as identified by the research based on flow theory [78]. In search of developing convenient IT plans for the elderly, a study [45] explored the importance of mitigating loneliness and isolation among the elderly when approaching design patterns. Another study discovered that key design components, including layout, colour choice, the amount of information on the home page, and content relevance,

have an impact on the user experience based on particular emotional values [70]. Similarly, it was found that the elderly perform poorly at VR tasks against kids due to a lack of technological understanding [26].

In another paper on the elderly during COVID-19, it was concluded that the most important factor influencing older people's quality of life is their mental health, and adopting ICT has a positive effect on these factors by minimizing social isolation [67]. In a research conducted by Ahmed and Sultana [46], rural elderly people of Bangladesh were observed to not use modern practices because of their incapacity to afford modern health, legal, and financial support. The intimidating design of modern fields made these generations believe there's a difference of class weighing against them integrated into the tech designs, making it expensive for them to afford.

In a study, SMASH– a set of 12 usability heuristics for smartphone and mobile applications– was applied within a controlled environment which showed 27 usability problems and 27 heuristic violations by the elderly. "Minimize the user's memory load" and "match between system and real world" were the two most frequently violated heuristics [37]. A paper on creating a TV user interface for older adults with chronic conditions developed personalized avatars like John, the diabetic persona, considering aspects such as perception, cognition, and mental and psychosocial changes that occur with age [11].

The elderly people not only face physiological barriers but also face technological barriers. Few studies on elderly learning suggest Cognitive load theory to be integrated while designing platforms for the elderly. The three types of cognitive loads, intrinsic- deals with the expertise of the learner, extraneous- deals with the superfluous processes, and germane- incorporates learning processes along with cognitive load; should be considered while designing an interface for the elderly [10]. Another study [1] suggests that instructional formats along with this cognitive load will engage elderly people and effectively manage their working memory capacity. Such design strategies, we believe, should also be considered while designing an e-health app. For improving the elderly's quality of life Llorach and others [44] discussed the complete build procedure of a web-based embodied conversational agent but the virtual agent had a technical shortcoming- If the model is in the cloud, the transfer of resources will take a large amount of time since there is a lot of data to be transmitted. Not only that but also there is a rendering complexity that is included in this system.

2.3 Design Strategy

To promote healthy ageing and improve several health-related outcomes for the elderly, a study [61] suggests smartphone-based interventions (apps) with persuasive design have the potential to bridge this gap. Most of the apps that are developed today are mainly for the younger generation because it does not fulfil the needs of the elderly. That is why we need a design strategy that targets elderly people. To improve user experience in the e-health domain, F. Carranza-García [40] proposes the concept of microservices-based technology that will promote reusability, under-

standing, and extensive use by the elderly. This research supports our endeavour to design an interface for our e-Health app that will be easy to comprehend by any adult.

A paper titled "Is a big button interface enough for elderly users" talks about how just making a button is not enough and discusses the importance of considering human factors for elderly people in software design, as the population of ageing people continues to grow [13]. So the interface design strategy of elderly smartphones should be based on user experience. According to Li, older adults faced challenges in directing their attention to menus and buttons, understanding the meaning of icons, and interacting with menu components [52]. The paper emphasizes the need to consider psychological factors such as loneliness, suspicion, and fear for designing mobile interfaces to provide a satisfactory user experience for the elderly and also talks about the need to consider the memory loss and reduced sensory functions of the elderly when designing interfaces.

When designing a software or interface for the elderly we need to design an interface that is very easy to use. The cognitive limitations of an elderly individual make it imperative to design consistent UIs with little to no irrelevant buttons or graphics to ensure familiarity with the app/ software [42]. A paper by Sanchez et al found the importance of balancing reducing scrolling with maintaining readability on small screens. The result showed that if the size of the font is too big that can increase scrolling and if the font size is less than 12pt it may reduce the ability to remember the text [12]. Similarly in another paper author recommended ten key areas such as - touch, gesture, speech control, clarity and layout, user guidance and navigation, text and language, graphics, animation, multimedia, links, searching, filtering, sorting, and consistency for design of mobile applications[33]. Additionally, Sakdulyatham et al deduced that Arial Unicode MS with a size of 16 pt., and a green tone screen with a 75% brightness level is the most suitable for the elderly [28]. For button size, it is recommended to use a 50x50 pixel button size regardless of gender [30].

In another study [53] it was deduced that elderly people found complex websites difficult to navigate due to their declining skills. It identified 82 per cent accuracy rate, clutter and equilibrium were vital features influencing complexity classification. In another paper, access to technology, particularly via voice user interfaces (VUIs) study shows that self-efficacy should be taken into consideration while developing VUIs to improve the user experience for older people [60]. Also, VUI design and feedback voice rate should be determined based on the speech rate of older users and the word count of feedback information [48]. Moreover, Wearable sensor technology's positioning of these devices is critical in modern medical fields [8].

In a paper, Wong, et al investigated that in Malaysia older adults with higher educational backgrounds are more adept at adopting the latest mobile technology and also highlights older adults' preference for metallic buttons over virtual keyboards [38]. Moreover, there is a demand for adaptive smartphone interfaces that target the elderly. Many common problems that the elderly face are - difficulty visualizing icons, inadequate labels, menu hierarchy issues, keys with multiple functions, and inadequate feedback [27]. According to Haikio et al after conducting an experiment where elderly users choose their meals for home delivery the result shows that the touch-based user interface was easy to learn and adapt and the users were able to successfully use it regardless of their physical or cognitive weaknesses [3].

Several research papers highlight the important areas to consider when designing for the elderly. Trust, Personal Integrity, Technology Acceptance, and E-health Literacy are some of the primary ones [39]. Fitt's Law in the research on HCI is also in line with the behaviours of old people [20]. Hence self-explanatory apps, considering the different abilities and needs, and the decline in the elderly's sight and touch [6] should all be kept in mind while designing comfortable technology for this age group. The paper by Fournier et al [50] investigated the gaps in user feedback and design knowledge in the SMART and ASSISTIVE technologies and suggested improvements in this field. Another paper suggests that despite accessibility and acceptance issues, collaboration between stakeholders can help enhance the quality of life for older people through smart technologies [76].

2.4 Tasks Associated With E-Healthcare

EHealth is the use of technology to improve health, well-being and healthcare. With the rise of the ageing population, the increasing prevalence of chronic conditions, and the ever-growing demand for accessible healthcare services, E-health apps stand at the forefront of a paradigm shift, offering a dynamic approach to healthcare service. In a paper Abelson et al identify various barriers to using a free mobile health app after an operation, including protecting personal information, concerns about technology failure or uselessness, preference for face-to-face communication with their surgeon, the level of effort required to use the app, and the ability of the elderly to navigate a mobile app [25]. In another paper, Alsswey and Al-Samarraie highlight the need to incorporate cultural values into UI design to promote user acceptance. Also talks about various theories, such as the Theory of Planned Behavior, the Technology Acceptance Model, and the Unified Theory of Acceptance and the Use of Technology to measure user acceptance [47].

Another study suggested that patient-centred e-healthcare using user-centred design (UCD) immensely enriched e-health marketing. Hence, focusing on patient-empowered, aware, and focused design is important to implement [7]. Moreover, Systems containing monitoring devices, smartphones, and a hospital information system that relies on Bluetooth technology are needed for the elderly to have autonomy [22].

The Internet of Things (IoT) plays a vital role for the elderly in smart living, connecting objects to provide adaptable and intelligent applications, impacting their social life and increasing their safety net as well [23]. Another paper [9] talks about the development of a device for evaluating broadcast background sound balance for elderly listeners, the design of a user interface for elderly people, and the design of a Portrait system to assist medical care staff in learning important personal information about residents in nursing homes with much success. In Roberta's study [51], an eHealth Mobile App for the elderly was designed and tested to emphasize the practicality of involving end users in the different stages of developing a design pattern by factoring in their unfamiliarity and hostility towards technology. This underlined the need to build mobile applications that ensure trustworthiness for elderly users.

2.5 Roles Of Artificial Intelligence In Healthcare

In the rapidly evolving landscape of healthcare, Artificial Intelligence (AI) has emerged as a transformative force, offering innovative solutions to enhance patient care and streamline medical processes. A paper by Ma et al investigated the importance of timely access to professional medical advice and the drawbacks of traditional in-person clinical visits. The results were very clear that medical advice services can supplement conventional health services from several aspects, including but not limited to facilitating navigation within the healthcare system, extending the scope of service to a broader domain, and fostering patient-doctor relationship [78]. Moreover, According to Panigutti [68] by observing the weight of advice, the behavioural intention to use the system, and the perceptions with quantitative and qualitative measures found that the results show a more significant impact of advice when an explanation for decision making. Similarly in another paper, the participants expressed the need for better explanations to help them interpret the system's confidence, verify the fit of the disorder suggestion, understand the reasoning chain of the decision model, and make differential diagnoses [18]. Another study indicated the potential of AI-driven DDSS in improving diagnostic accuracy and reducing cognitive biases in the diagnostic process [55].

According to Eiband et al placebic explanations for algorithmic decision-making may invoke perceived levels of trust similar to real explanations. This finding has implications for the design of explanations in human-computer interaction and raises questions about the use of empty explanations as a psychological tool to soothe users [41]. In another paper factors like - task complexity, technology characteristics, and perceived substitution crisis, as well as health professionals' characteristics factors influence the adoption behaviour of healthcare professionals and organizations when it comes to adopting artificial intelligence-based medical diagnosis support systems [49]. Moreover, another study emphasizes the importance of understanding users' behaviour to inform the design of user-facing systems and machine learning models [58]. However, the paper by Jacobs et al revealed that interacting with ML recommendations did not significantly improve clinicians' treatment selection accuracy compared to baseline scenarios [56].

A paper by Guidotti et al discusses the issue of black box decision systems. The paper emphasizes the need for meaningful explanations of the logic involved due to its impact on ethics, accountability, safety, and industrial liability [43]. A paper by Lakkaraju and Bastani demonstrates how these explanations can manipulate user trust and the study shows that misleading explanations can increase user trust in black box models by 9.8 times [77]. Another paper underscores the importance of auditing clinical decision support systems (DSS) to ensure fairness and mitigate biases, emphasizing the potential impact on end-users [62].

2.6 Benefit Of Age-Sensitive Design

In an era marked by technological advancements, the intersection of healthcare and digital innovation has paved the way for transformative solutions, particularly in

the realm of elder care. With the power of technology, a lot of the problems such as social connectivity, and personalized care can be easily solved. In this context, the benefits of E-health apps for the elderly are far-reaching, offering a comprehensive and user-friendly bridge between seniors and the healthcare resources essential for maintaining a fulfilling and healthy lifestyle. A written paper about Interface design for elderly people proposes the concept of a user-configurable interface that can adapt to the visual, auditory, haptic, mobility, and cognitive abilities of elderly users can improve their independence and quality of life [17]. Another paper identifies multiple possible benefits including better monitoring, improved communication with their surgeon, minimized follow-up visits, and overall improved convenience with their care [6].

In another paper, Liljeroos and Arkkukangas [73] implemented telemonitoring in health care for older adults and the results were predominantly positive, showing a favourable response from the healthcare profession. Gemert-Pijnen et al emphasize the empowering effect of eHealth on patients, enabling them to become more active participants in managing their health and well-being so that they can enjoy benefits like Access to care, innovation and empowerment [34]. Additionally, a recent study found that economic evaluations of eHealth applications are gaining momentum, and there is considerable variation regarding the costs and benefits included in these evaluations [64].

2.7 Prospect In The Healthcare Industry

There are many apps related to E-health that can be found in Play Store or other platforms but almost all of them target the young generation. So there are a lot of opportunities for us to improve in this sector. Papers by Conway et al prove the point that the majority of older adults found the concept of technology for medication-taking or medication reminder appealing, and most owned smartphones but did not actively use apps [32]. Similarly, another study revealed that elderly users expect reminder systems to be simple, familiar, flexible, and recognizable [14]. With the technological advancement of this century, integrating e-health into an elderly lifestyle might retrospectively reduce costs and overall enhance the well-being of the elderly. A study suggests smart environments and providing age-friendly care services can improve an elderly's quality of life [48].

Clara Li [59] acknowledges that current design strategies fall short of compensating for the existing mobile health applications. More research needs to be done to improve accessibility for the elderly and feasibility of use by the elderly. Hence, we aim to contribute in this sector and help the elderly to improve their lifestyle and eliminate intimidation to integrate technology into their life.

Chapter 3

Preliminaries

In this chapter descriptions about the technologies and concepts that we have used in our research are going to be described. Technologies such as Large Language Models based on GPT architecture, Rendering engines as a multiplatform rendering application generator, Tunnels for experimental setup and Customized Python SDK for thread handling of Open AI's Assistant API and RAG were used.

3.0.1 RAG: Retrieval Augmented Generation

Retrieval is a tool of Open AI Assistant. The function of retrieval is to retrieve information from a given resource.[75] On top of its knowledge base. Open AI's language model is trained on multi-billion parameters making it one of the largest LLM models. However, often time to generate a curated response for a certain organization the necessity of an external knowledge base appears. In this case, the Central Hospital's website contains the latest data resources for its services. If we try to generically gain access to these resources the LLM fails to generate a response from its base as it is limited to the resources of 2022. To overcome this, Open AI has introduced Assistant where we can run functions, Retrieve knowledge and implement code interpreters. For this research, the tool of Retrieval is used.

[Realm paper] Open AI assistant uses a Retrieval Augmented Language model to generate Data from a user-given data source. This works in such a fashion that it tries to predict the missing word from a given user prompt. For example when a user asks "My Grandmother is having Cardiac issues" it tries to find out the sequence to sequence missing information.

The prompt is given to the Open AI assistant: "You are a helpful assistant, you generate empathetic responses from your knowledge base based on the symptoms given by the user you suggest a doctor" The knowledge base contains data like, "Dr Lipi Debnath Cardiologist" The Sequence to Sequence of Assistant tries to complete the user prompt and predict a result Where it generates "You need to consult a cardiologist" After which it searches from the knowledge base based on the generated sequence to sequence prediction. Sequence to Sequence Incomplete response: "You need to consult a cardiologist [MASK] ." Resource File: "Dr Lipi Debnath Cardiologist" Sequence to Sequence Complete Response: "You need to consult a cardiologist, Dr Lipi Debnath is a cardiologist, you can visit her"

Open AI assistant breaks each resource of the knowledge base as chunks otherwise if the given file is a simple text it includes that in the system prompt. This reduces the need to create a base maintained with perfect sequence. Thus whichever order the resources are it scans through all the resources to produce a valid and quality response.

3.0.2 GPT Architecture

Open AI LLMs like ChatGPT and Assistant API use the sequence-to-sequence response generation as mentioned previously.[75] However, it uses a GPT 3 architecture. GPT 3 Architecture uses next word prediction which is built in an unsupervised training manner. It uses its decoder blocks to decode its responses in training and tries to match them with the exact output that it was supposed to produce. After which the network keeps the biases for a certain set of vectors which it is supposed to decode from its base of 570 GB worth of texts. It uses its sets of decoders to produce the next word and in a failed validation case it then restarts its prediction mechanism. Even though the weights and biases are kept for future use this might happen that for a certain set of words, it is unable to generate a response but as it's trained in an unsupervised manner this system can do constant training. This is one of the reasons the GPT architecture can generate curated responses from a certain set of resource blocks it has never seen before. Below is a visual representation of how the system predicts the next words,

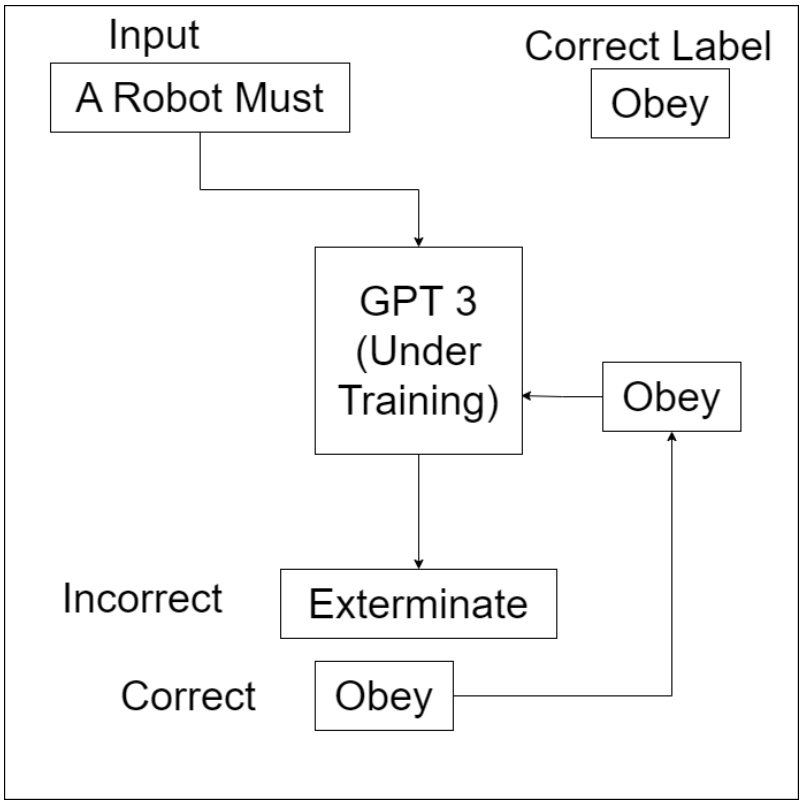

Figure 3.1: Diagram of GPT 3 Training

However, GPT Architecture alone does not account for the sentiment analysis of input prompts and response generation. The model we used in our application is Chat GPT which is based on the GPT Architecture additionally it is trained on reward reward-based system for response generation.

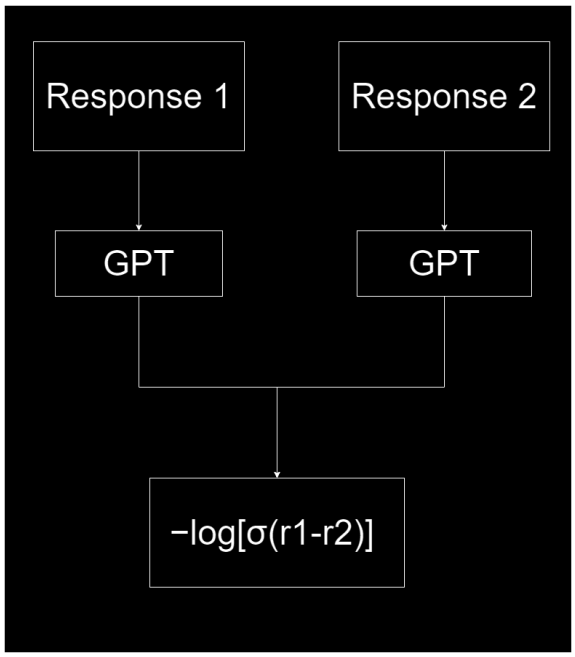

Figure 3.2: Reward Based Model

Finally, it initiates Proximal Policy Optimization(PPO) using RLalgo. In this phase, the reward-based trained system gets the input from the initial GPT response which is used to Optimization of responses. Hence, the system can be tuned to dictate the quality of responses. Thus it generates human-like responses.

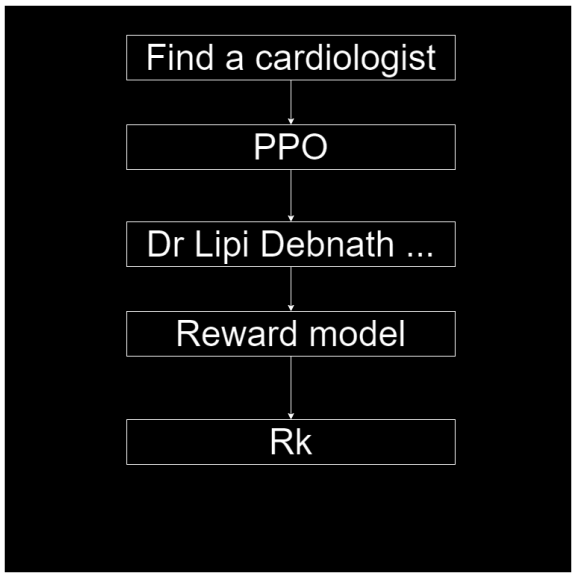

Figure 3.3: Complete Training Flow

3.0.3 Open AI assistant

Open AI's assistant is an extension of its language model. As discussed in the section of RAG open AI introduced its assistant under the branding of mini G for individuals and organizations. The assistant uses its flow differently than the completion API. Where in completion API takes the System, User and Assistant prompt assistant use its flow differently which is thread-based. The thread takes in an assistant ID. The assistant can be assigned with user-generated files.

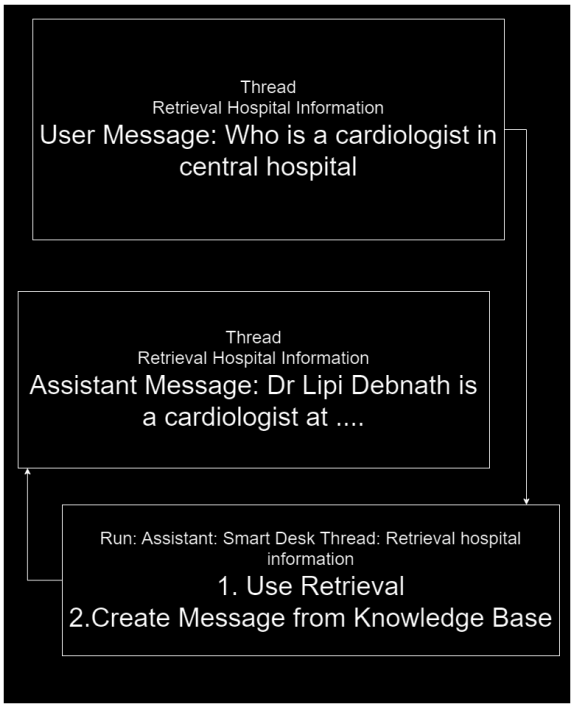

Figure 3.4: Open AI assistant Workflow

The figure of Open AI assistant Workflow contains a sample input of our application which suggests the appropriate doctor according to the user's request. Here the components are divided into some segments. Such as Threads and Run segments. In the workflow of Open AI assistant, Initially, a thread is created with the assistant ID. The assistant ID is fetched from the dashboard of the Open AI user account. With the dashboard, we attach files to the assistant. The created assistant is now ready for response generation. After which we create a run object in our programming and we run the run object. The run object then returns a response that is added to the thread. We can call the thread again to see the response that is added to the thread. This approach is different from the approach of Open AI chat completion API. The Chat Completion API does give a thread ID however it does not track the previous messages. To do that we have to add the previous messages in an array list after which it generates connecting responses. One problem with this approach is it creates a max token limitation issue. However, the latest implementation of open AI assistant in a thread system is much better at handling these issues.

3.0.4 Website to Data set conversion

For this research we had to convert the hospital website-provided data to organized data. Even though Open AI assistant can take data files such as HTML which the website filetype already is. However, we preferred to first make a CSV for the doctor's details and a PDF with the extra data. One reason is that webpages have additional strings that the assistant has to parse such as the HTML non-table elements and the Javascript attached to the file. This might have created a wrong response problem or the token limit could've finished. To prevent this we preferred to use PDF and CSV files for the relevant works. The reason we selected CSV for the doctor's dataset is that the data in those fields are classifiable and it will create more connecting responses to the provided labels. One issue we faced in this segment with PDF is that some doctors are working at two different hospitals at the same time. The given visiting hours are for the central hospital though, however, the system gets confused in generating the location of the doctors and it sometimes suggests the second workplace that the doctor works in.

To prevent it we decided to provide labels on top of the relevant data. As the doctor's data was classifiable we classified it into the segments of Name, Department, Description, and Visiting hours. In the CSV document, all data are taken as a string input.

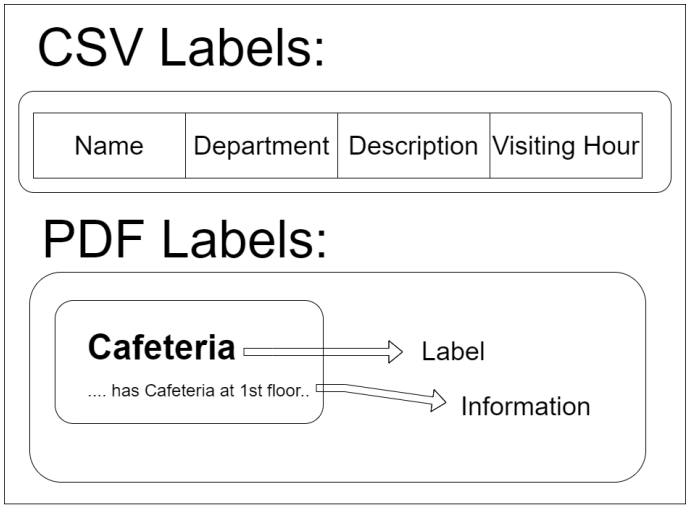

Figure 3.5: Visual representation of the Dataset

In this dataset, all the information is taken from Central Hospital's website and classified into the presented labels. We have provided all the inputs as strings because the Open AI retrieval model is based on Chat GPT hence it uses the next-word prediction mechanism. If we provide strings as input the detection of a suitable answer becomes easy. Otherwise, since it's a language model it has to convert the data into string type and then process. For the data language, we have kept it in English. Since the default it was trained on is English.

After this phase, the doctor dataset was converted into HTML. Which is classified into table head and table data elements which remove the requirement for parsing through extra data. We upload a supported PDF of the doctor dataset this is

because we surprisingly found out that these two different formats of the same data file help each other in the training phase.

However, when we tried with the PDF only because of a large table that is included in the PDF the assistant was unable to extract the information. This does not happen with the small data set. With a large data set, we assume that this is a PDF parsing limitation. Which then gets eradicated when we pass the HTML file.

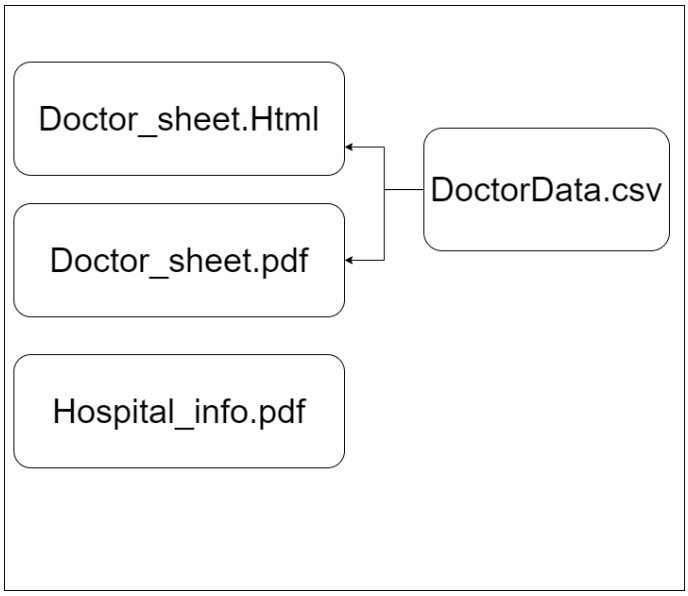

Figure 3.6: Representation of Dataset for the Assistant

Here we can see that the Doctor_sheet.html and Doctor_sheet.pdf both were generated from a single DoctorData.csv. We performed this with Google spreadsheet export functionality. Additionally according to the PDF labels we have generated the Hospital_info.pdf which hosts other data regarding the hospital.

3.0.5 Multi-Platform Rendering Engine

Applications nowadays come up for various platforms such as Android, IOS, and Windows. For seamless testing, we had to build an app that would support all the channels for the research. It was too tedious to make an app for all the platforms differently hence we preferred to use some existing multi-platform rendering engine. There are quite a few of those in the market such as Unity, Unreal Engine, and Flutter. For simplicity, we chose Flutter for the job. Flutter is a widget-based rendering system which means that every component is a widget in it. We did use some additional packages to make the application such as Dash Chat 2 for the Chat screen functionality. Open AI SDK for the chat completion API. Which in our app is marked as a Primary Care bot. However, we were unable to find an SDK for the Smart Desk. Which is used with the Assistant API. Hence we had to make a custom SDK with Python which would do this job. In the backend of the application.

3.0.6 Customized Python SDK

For the research, we had to make a customized Python T SDK that would handle the requests from the client and deliver them to the assistant get the response of the assistant, and deliver it to the client. Thus it is sort of a bridge that will act as a completion to the currently incomplete channel for the Open AI assistant. For this, we had to create a server. We used a flask for it. To create an API. We take the JSON post request to the server from the client take the content pass that into the thread that we initially created. Then we run the thread. After this, we manually kept a while loop which will listen to the change in the thread with the response. Because currently the Open AI package only comes with the thread. It does not stream, hence there is nothing we found regarding that which will make the function run in sync. Hence manually we implemented this and kept the waiting for 0.5 Seconds. After which we serve the content to the requester client. Questions might arise why are we initially creating the thread? This is for research purposes. The open AI assistant in a free tier has a limitation of 3 threads per minute and since our experiments did not require more than that we are creating the thread initially. Also in the existing thread, the error can be traced. For any error, the thread keeps on repeating the same response that it last held. Hence we can restart the thread and fix it. Since it is for research this is viable. However, for production, this is not recommended at all.

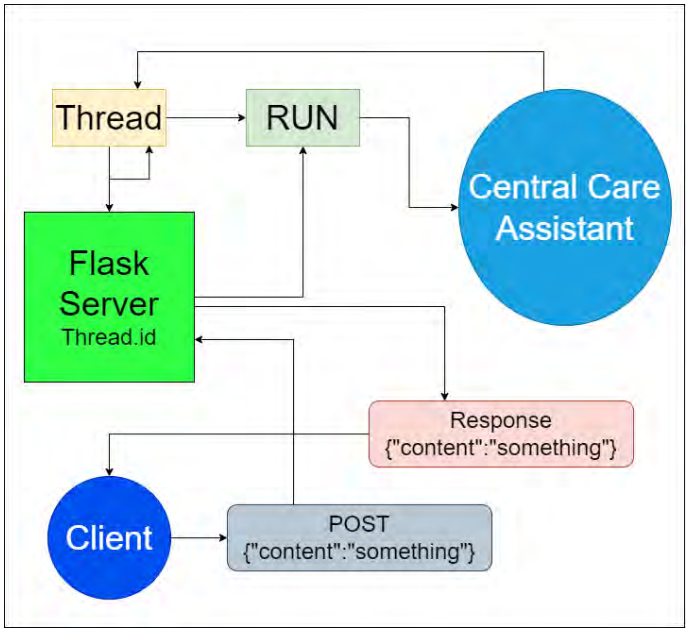

Figure 3.7: Server Client Architecture with Customized Python SDK

3.0.7 Tunnels

Tunnels are used to expose a local server to the World Wide Web. It generates a public HTTPS link that we can use to access our locally run services. This is crucial to test the system in a broad location. Since carrying the server is not possible

everywhere thus accessing the server with one router using Lan becomes impossible hence there have to be alternative ways.

Yes, it's possible to use a cloud service but this creates another issue which is restarting the cloud server every time it fails for the thread issue or hallucination. Hence, to eradicate this, our research uses a tunnel to do the job. For this purpose we used Ngrok. The reason is this is free and it gives us a HTTPS link. Which is secure and thus the flutter built-in internet security algorithms do not throw errors. For research setup, this is assumably the most economically viable setup with almost zero cost attached. However, for production setup, this is not at all recommended. There are huge security risks attached to it.

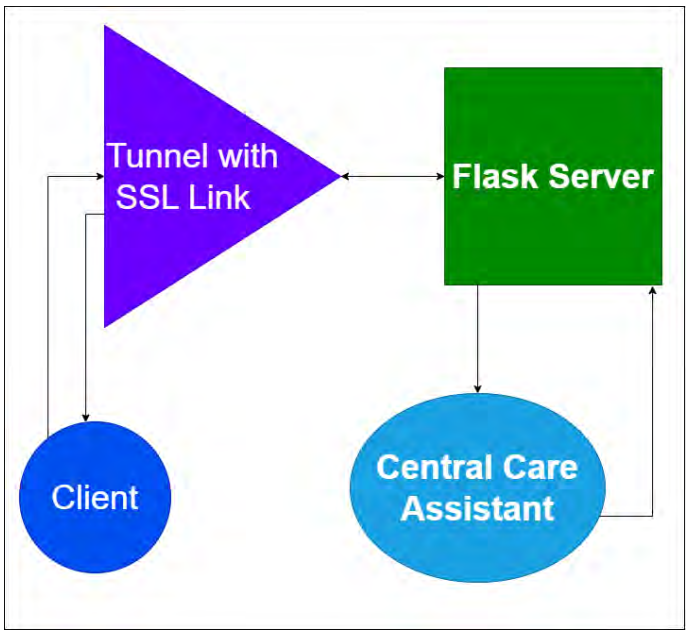

Figure 3.8: Complete Work Flow of the System using Tunnels

Chapter 4

Research Methodology

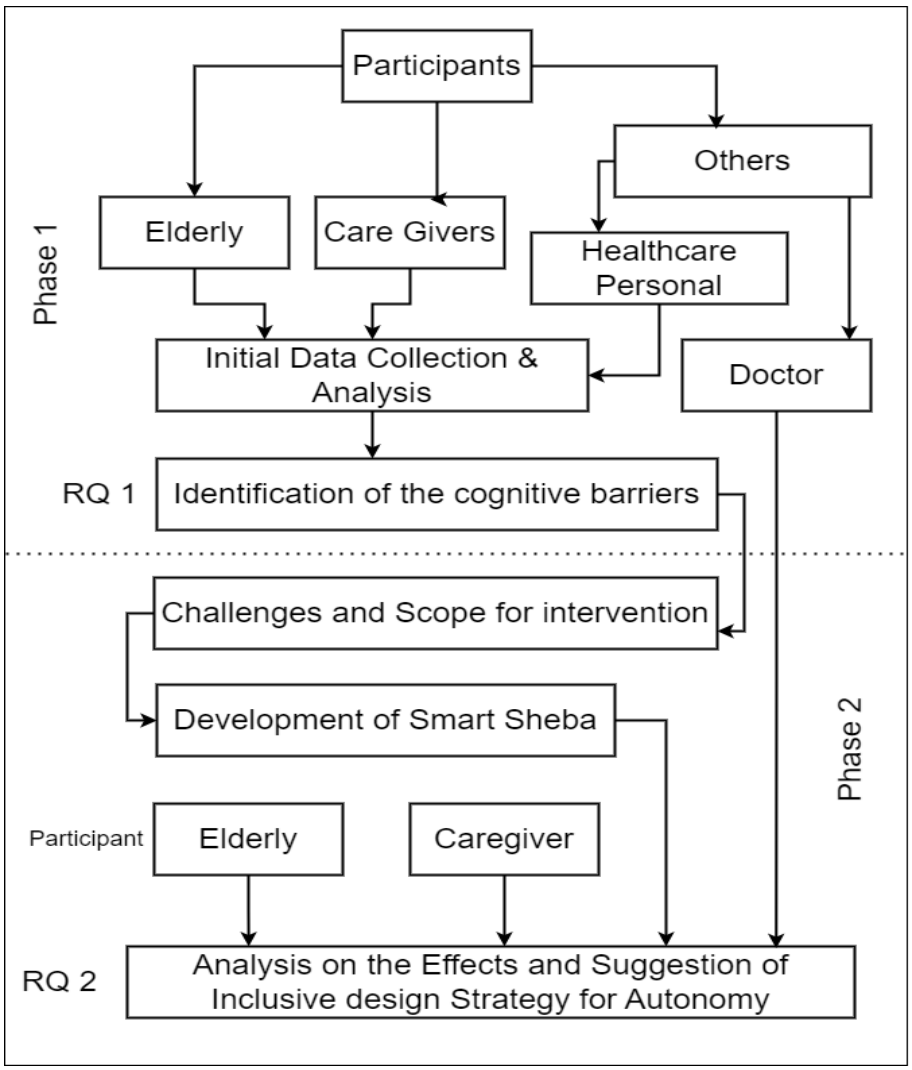

Figure 4.1: Workflow

4.1 Participants

We mainly focused on the elderly as our primary group and took multiple data on their smartphone usage. As our goal is to create a user-centered design strategy we have to take data multiple times from the elderly. We also took some data from caregivers of the elderly, hospital reception, and doctors. Not only can they impact the elderly, but they also contribute to a deeper understanding of how E-health technology/apps are utilized from Bangladesh's perspective.

4.1.1 Elderly People

First, 3 of our interviewers (2 male and 1 female) started gathering data of elderly who are between 55 and 80. They have collected data from 32 elderly of which male is 20 and 12 female. We conducted our interview in Bangla as it is the mother tongue of Bangladesh. We also divided them based on their literacy. As they were our main target group we only made divisions based on literacy for the elderly. We used the data to further understand the perspective of the elderly.

Then after completing our final app, we took the app to the elderly to get another set of data to better understand the positives and negatives of the app. There, we took interviews from 18 elderly people of which 12 were male and 6 female.

4.1.2 Caregiver

As caregivers also play a crucial role in the life of the elderly and play a huge role in taking care of the elderly, this additional information aims to provide a deeper understanding of how the elderly utilize smartphones. Our 3 interviewers collected data from 19 caregivers aged between 20 to 45 from Dhaka, Bangladesh. We also conducted our interview in bangla. Similar to the elderly after finishing our first app we conducted another interview with the caregivers to get their perspective on our app and how it would help the elderly.

4.1.3 Doctor

As we are trying to create an e-health app for the elderly, we wanted to ensure that our app feature can help from a doctor's point of view as they are the ones who are most skilled in this sector. We only managed to cooperate with 3 doctors of which 2 female and 1 male. Due to the high workload and concerns regarding the safety of an unknown AI app, we faced challenges in securing the participation of numerous doctors.

4.1.4 Healthcare Personal

To better understand how most of the people in Bangladesh book appointments for doctors we decided to get feedback from the healthcare receptionist. As they have a lot of experience and have seen how people operate they could provide us some unique insight. we took surveys from 6 individuals of which all 6 of them are male.

4.1.5 Consent

We briefed the participants about our study and took verbal consent from them before data collection.

4.2 Initial Data Collection

To do an in-depth investigation into our topic we utilized the following methods to collect our data. At first, we had to identify the scopes in HCI, the healthcare field related to the elderly. For this, we collected sets of data to give us an understanding of the scopes to form our baseline idea. We divided the question sets into Qualitative and quantitative data to have an insightful understanding. Additionally, we collected demographic data. Sets of questions were asked to both Elderly participants and their caregivers.

From the sets of questions, we investigated the barriers in the usage of applications from the perspective of the elderly and the perspective from the caregivers to their elderly. To have a deeper understanding of our target group we collected their demographic data which includes their age, Places they live in , Their Smartphone usage and activities they do in their smartphones. We also collected the obstacles that they face during the usage of their smartphones. We also gathered data to understand the care giver's viewpoint on the usage of smartphones by the elderly. We also interviewed appointment booking professionals to understand their workflow. **Analysis of these segments of the data will give us a clear picture of the cognitive barriers that the elderly face in their usage of mobile applications in their day-to-day life**.

4.3 Assessment of Smart Sheba

Based on both of the Applications we devised 3 tasks for the elderly and the caregivers to test our concept. In the floating action button, we kept the assistive information. We taught them the usage of the Floating action button assistant before asking them to do the tasks.

1. Navigate to Smart Desk and for your current/previous symptoms find a doctor from central hospital
2. Navigate to Primary care and for your Current/ previous symptoms ask any questions and have a conversation with it exactly three.
3. Call the appointment booking number using Emergency Contact.

Exception in Assessment:

The test will have some exceptions because of the multi-segmented population based on their education and technology literacy barrier, that is for those, who face difficulty typing. We will use the Redmik keyboard's voice typing feature and make them speak instead of typing. Herein, we will help them in this procedure and for

the population who never used a smartphone and does not understand anything or is unable to read, we will play the assistant for them.

4.4 Numerical Assessment Procedure

We are following several assessment strategies for our application. To prove our concepts and meet the objectives. Firstly we are doing UCD screening numerical analysis. This requires data such as Success rate, Error rate, and Completion Time. After which we are also assessing the capacity of the LLM response capability. For which we are doing an Accuracy and Performance analysis. For this, we need the Rate of Success and Hallucination for Accuracy and for Performance, we need Failure Rate and Response time.

4.4.1 UCD Screening:

For the tasks we provide 1 point if they are successful and measure it as the success rate and if they fail, we assign 1 as the error rate and measure the time in seconds for all cases.

Formula: Success rate = Sum of(Success Point)/3, Error rate= Sum of(error point)/3, Completion Time = Total time required to complete the task.
Example: Let's say the participant has successfully done 3 tasks in 20 Seconds hence the success point total will be 3, an error will be 0, and the Completion time =20 Seconds after which we will convert the success point and error point to success rate and error rate to the range of 0-1 by dividing it by 3. Hence the success rate will be 1 error 0.

4.4.2 Likert scale

A Likert scale is a survey tool with statements and response options, typically ranging from "Strongly Disagree" to "Strongly Agree." Respondents select their level of agreement, helping researchers measure attitudes or opinions on a graded scale. It provides a quantitative representation of subjective data for analysis.The question asked elderly are

4.4.3 SUS(The System Usability Scale)

SUS (System Usability Scale) is a widely used questionnaire for assessing the usability of a system or product. It consists of ten questions with a Likert scale, providing a quantitative measure of user perception and satisfaction. Higher SUS scores indicate better usability, while the scale allows for benchmarking and comparison across different systems.

4.4.4 LLM analysis

We are going to assess the LLM on the Metrics of Mean Accuracy-Performance Analysis, We have devised a simple formula for it. Here the analysis is happening on Failure Numbers, Hallucination, and Response time.
Failure rate is the rate at which during a request by the user, the server fails it's particularly different from hallucination which produces wrong answers for a particular task, and response time is the total time required for the response to complete. This starts from the end of the request to receiving the complete response. Now we have devised a pointing system for the Accuracy-Performance analysis.

4.4.5 Mean Accuracy-Performance analysis:

We have assigned 200 points total and the 200 is divided into two parts 100 points for accuracy and 100 for performance.
Here is the formula,

$$Accuracy - PerformancePoints = AccuracyPoints + PerformancePoints$$

$$AccuracyPoints = SuccessPoints–HallucinationPoints$$

$$PerformancePoints = ResponseTimePoints$$

$$Mean = Sumof(Accuracy–Performancepoints)/N$$

N= Number of Requests
Response Time Points Table: Less than 4 Seconds = 100,
Less than 6 Seconds = 80,
Less than 8 Seconds = 75,
Less than 10 Seconds = 50

Example: Let's say there are 3 Participants, Each participant sent 4 Requests. If all participant has a Response time of an average of 6 and amongst 4 requests 2 requests were completely accurate 1 response was not so accurate 30% hallucination Occurred and 1 Request failed.

Accuracy for request 1 and 2 1̄00, Response Time Points=75
Accuracy for request 3 = 100-30=70, Response Time Points =75
Accuracy for request 4 = 0, Response Time points =0

Total Accuracy – Performance Point = (175*2) + (70+75) + 0 = 495
For 1 participant Mean Accuracy – Performance Points = 495/4 = 123.75

If for all the number is 123.75
Then for all the Mean Accuracy Performance Point = 123.75

In our research, we are going to assess the capability of the LLM both Chat Completion and Assistant over the Bengali and English Language capability.

4.5 Qualitative Analysis

We are taking qualitative data from the elderly and the care giver along with the healthcare professional. We have collected all the comments from the elderly to do a thematic analysis on them. By doing the thematic analysis we would be able to understand the underlying theme from the elder's comments. Which would help us to create a better design for the elderly. Also we are have categorical data distribution in our results. For those data we are doing data visualization to reach to a particular conclusion.

4.5.1 Thematic Analysis

Thematic analysis is a qualitative research method that involves systematically identifying, analyzing, and reporting patterns within a dataset. Researchers immerse themselves in the data to analyze the content and generate initial codes to label interesting features or patterns. These codes are subsequently organized into themes, for a higher level of interpretation. Through an iterative process of reviewing and refining themes, researchers ensure that they accurately represent the underlying patterns within the data.

4.5.2 Categorical Data Visualization

For understanding the categorical data distributions we are using categorical Data Visualization. In this process we are using graphs to visually represent the distribution of categorical data. to reach to conclusion.

Chapter 5

Experimental Evaluation

We now present our research findings for older adults and caregivers to identify the obstacles older adults encounter when using smartphones.

5.1 Outcome of the interview with the elderly

In this segment,t we are evaluating the demographic and background data of the elderly to have a better classification of our data. We want to understand what type of activity they perform on their mobile phone and access to mobile phones so identification of familiarity will be easier for us.

5.1.1 Demographic Data Of Elderly

We interviewed elderly people between 55 and 80. Among the elderly, 50% (16 out of 32) were between 65 and 74, 43.8% (14 out of 32) were between 55 and 65, and 6.3% (2 out of 32) were between 75 and 80. Age is an important factor in smartphone usage because the elderly, who are younger, have a better chance of getting in touch with smartphones and technology. We also categorize the elderly based on their education. If the elderly had completed 10 years of schooling or more, we considered placing them in literacy. Less than 10 years of schooling to more than 5 were considered semi-literate, and less than that were considered illiterate. Literacy serves as a pivotal measure to comprehend how older individuals engage with smartphones. By categorizing the elderly, we would be able to identify how technology or smartphone usage varies and what their effects are. Also, from the data we collected, we can see that 6 males and 2 females were literate, which means that they had completed 10 years of schooling or higher. Most of the elderly interviewed—precisely 11 males and 9 females—were semi-literate. Lastly, only about four elderly people were illiterate.

5.1.2 Background of Elderly

We have collected the data from different places. But a lot of the elderly data came from the elderly, who are situated in the Dhaka Mohakhali area. Most of the participants that we interviewed came from different places. They all came to Dhaka

to earn their livelihood. These seniors pursued various professions throughout their lives. A lot of the elderly were businessmen and salarymen. Many of the elderly are retired and spend their time at home. From the data we collected, the majority of the elderly were Muslims, and they all spoke the same language, which is Bengali. As the majority of the elderly in Bangladesh.

5.1.3 Elder's smartphone usage

Currently, we possess limited knowledge about the backgrounds of elderly individuals. Therefore, we inquired whether they have prior experience with smartphones to identify those who are more acquainted with the smartphone interface. This question also helps us determine the level of technology literacy among our participants. Now, among the 32 elderly, only 4 have any prior experience.

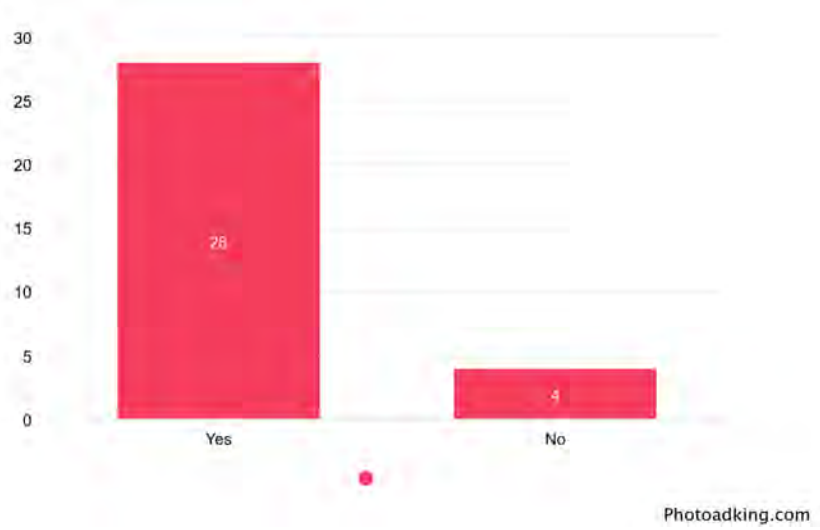

Figure 5.1: Experience of using smartphone

In addition, we wanted to better find out why the four elderly people did not use smartphones. We are systematically categorizing the responses to ensure a conclusive answer. Two of the elderly responded that they do not understand smartphones very well; one of the elderly thought it was very expensive, and the last elderly thought it was too complex for him. An elderly person shared with us,

"I am too old for a smartphone; it is too complex for me and I just use my phone for communication so I don't need a smartphone."

Moreover, a common theme among these respondents is the perception that smartphones are too intricate for their use.

In addition, the frequency of the elderly's usage of smartphones is also related to their familiarity with the smartphone interface. This is qualitative data, which helps us get a better understanding of elderly smartphone usage. Among the 28 elderly who have experience with smartphones, 8 of them use smartphones less than 1 hour, 14 of them use smartphones less than 3 hours, and 6 of them use smartphones less

than 6 hours. None of the elderly who we interviewed used smartphones for more than 6 hours. So it showed that the elderly use less time on their smartphones.

To better understand the preferences of elderly people, it is important to know what type of activities they perform on their smartphones. Designing an ideal layout is dependent on the data collected during the research, as it will help assess the familiarity of our user base with the user interface (UI) layout, which plays a vital role in user-centered design (UCD). The data provides crucial information about this demographic and helps us understand the type of activities our users engage in. This, in turn, will enable us to make informed decisions in the design process.

Our findings show that elderly people mostly use their smartphones for communication, social media, and entertainment. 100% of the elderly use their smartphones for communication, 84.4% use them for social media, and 40.6% use them for entertainment. There are other types of activities that elderly people engage in as well, but these are in smaller percentages. This data will serve as a foundation for building the UI layout of our design to best suit our user base.

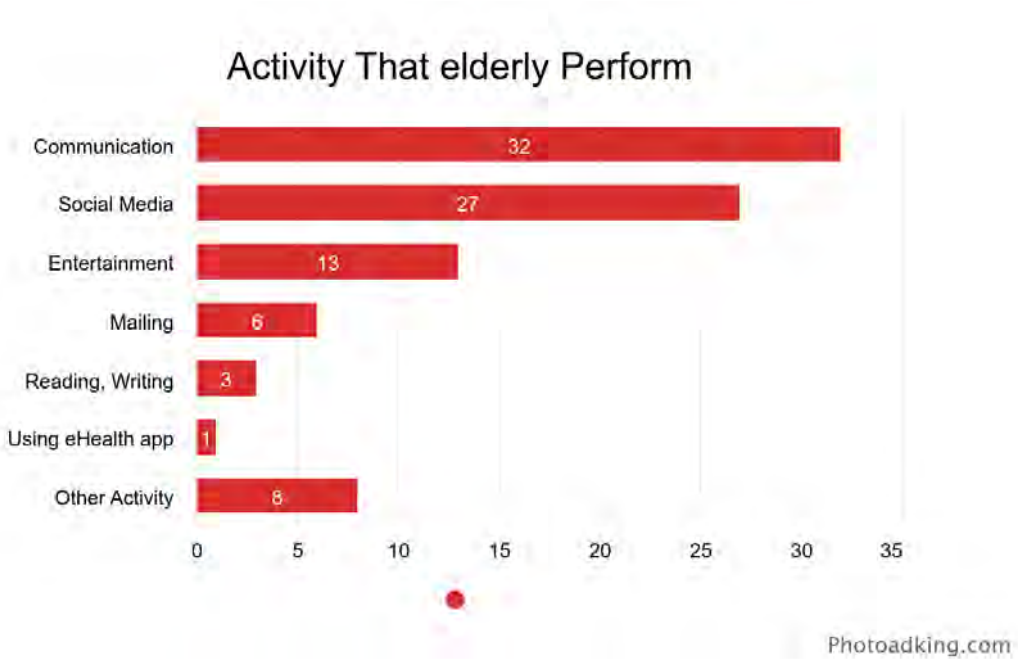

Figure 5.2: Activities performed by Elderly

Now we are familiar with the elderly and understand their background. As the elderly also became more familiar with us, they were more comfortable sharing their experiences with us. Now we want to find out the cognitive barriers that the elderly face. So now we asked the elderly the question that would help us find the barriers they face.

5.2 Obstacles encountered by the elderly

The color and color contrast also affect the elderly when they interact with the interface of the smartphone. As the elderly get older, their physical capabilities, such

as eyesight and motor skills, decline. So it is very important to clearly understand their color preference; otherwise, it would become a barrier. Because the color text is not clear enough, it can hamper their smartphone experience. We found that the majority of the elderly—about 84.4% of the elderly—wanted vibrant colors, and 16.6% of the elderly wanted black or darker colors. Which matches previous research results. It would help us in designing our app.

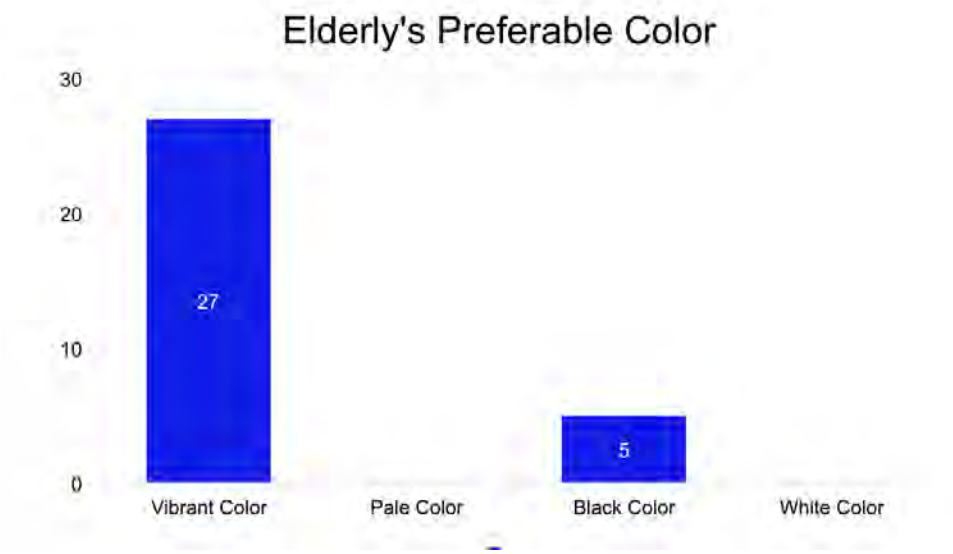

Figure 5.3: Color Preference of Elderly

As almost all the apps have icons, to confirm if icons and numbers are necessary for the navigation button, we asked them If the elderly felt it was easy to navigate and everybody replied positively, this indicates that if there are fewer icons, it can increase the cognitive load.

Also, we wanted to find out what frustrations the elderly face when using smartphones. It is a qualitative question, as we want to evaluate the problems the elderly face. So we did a thematic analysis of the data, and we used codes and their frequencies to analyze the data.

Theme	Frequency
I cannot understand the function of different icons	7
Forgetting the steps to use app functionality	19
Too many buttons and information	15
The icon and text are small and hard to understand	22
Other Functionalities	13

Table 5.1: Elder's Frustration

The results found that 68.8% (22 out of 32) elderly people complained about icons and text being too small. So we can say that the majority of the elderly face this problem. This means that because of this problem, a lot of the elderly cannot use the app very well. As the eye vision of the elderly declines, this problem will steadily increase, which will further create a barrier for the elderly while using

smartphones. Another barrier elderly people face is forgetting the steps to use the app's functionality. 19 (59.4%) of the elderly face this problem. It is also a problem that will increase as the elderly get older.

This can be a significant problem as applications these days have a lot of features. So it would be very hard for the elderly to remember them, which would negatively impact the elderly's psychology. Approximately 46.9% of the elderly found that too many buttons were very frustrating. Which can be very confusing for the elderly, due to this, the elderly would make more mistakes while operating a smartphone. In addition, 21.9% of the elderly did not understand the different functionality of different icons and buttons. It can be due to different reasons; the most prominent one is not having technological education. Technological education is necessary for understanding different features of apps, and as many elderly do not have them, they cannot utilize many functions of smartphones. And lastly, 40.6% were frustrated with many other features of the smartphone.

With these, we were able to identify major problems the elderly face when using smartphones. These problems are the main factors that lead to elderly cognitive barriers. To further investigate, we wanted to have a different viewpoint, which is that of the caregiver. As they spend more time with the elderly, they know much more about their needs.

5.2.1 Caregivers Viewpoint Of The Obstacle Elderly Face

Even though caregivers are secondary participants in our study, they are one of the crucial pieces to understanding the perspective of their elderly. First, we took data for their age. The age range of the caregivers was between 25 and 45. Then we proceeded to learn about their educational qualifications to better understand them. There were 11 males and 8 females among the caregivers that participated in the interview. Out of the caregivers, 6 were literate, 8 were semi-literate, and 5 were illiterate. The caregivers were mainly family members of the elderly. They have many different jobs like salary man, businessmen, etc. The caregivers that we interviewed mainly live around Dhaka. They are a key figure in the elderly's life as caregivers take care of their needs.

Then we wanted to figure out how much the elderly rely on caregivers for their technological needs. This would provide us with key insight into the dependence of the elderly on technology. A caregiver shared that,

"I need to help my father regularly, as he makes calls to my brother abroad and usually helps him send pictures in Messenger."

The interview results show that 26.3% (5 out of 19) of the elderly take regular help from caregivers. In addition, the majority of caregivers, or, to be precise, 57.9%(11 out of 19), help the elderly quite often. This shows how much the elderly are dependent on caregivers. And caregivers help with their technological needs.

Among the caregivers, 89.5% expressed that they help the elderly with texting and 84.2% help them with their social media. About 57.9% of caregivers help the elderly with communication and other features. This data indicates most of the elderly face problems texting and using social media, and they face many problems when using

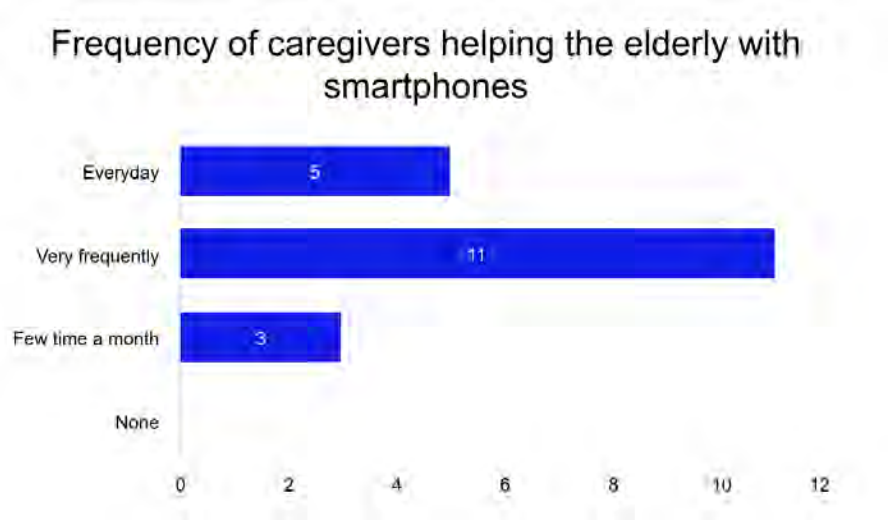

Figure 5.4: Frequency of Caregiver Helping The Elderly

them.

Caregivers also shared many different problems that the elderly face when alone on their smartphones. By thematically analyzing them, we found the codes.

Theme	Frequency
Navigating through complex interface	4
Using different features of social media	6
Changing smartphone settings	3
Forgetting the functionalities of an app	2
Booking an appointment	2

Table 5.2: The challenges observed by caregivers in the elderly population

Connectivity is very important, and to connect with other elders, you need to use a social media app. But 6 out of the 19 caregivers told us elders facing problems with this social media means that many of the features of the app are very complex for the elderly. It also tells us that a lot of the elderly find it very difficult to navigate through complex interfaces. So we can say that the complex is one of the big problems that the elderly face. Similarly, as three of the caregivers explain to us, the elderly face problems in changing settings; it can also be due to complex layouts. Lastly, forgetting apps' different functionality can be credited to older age. Through in-depth thematic analysis, we can see that complex navigation is the biggest problem that the elderly face.

From previous results, we have a general understanding of the issues older people have when using smartphones. As this research designs an e-health application to resolve the issues in UI design that the elderly experience, we will now look into the obstacles that the elderly face in the e-health sector so they can use smartphones to get assistance in the healthcare industry. Therefore, in order to fully comprehend the issue of the elderly, we acquired data by posing the following queries.

5.3 Challenges Encountered By The Elderly When Using E-health Application

While taking interviews of the elderly about their smartphone usage we wanted to get a clear picture of what the elderly think about e-health apps. And also find out if they face any kind of problem with the e-health sector. Though many of the elderly are familiar with telemedicine but they are not that familiar with e-health apps. One of the elderly was not even interested in talking about it. He explained,

" I don't care about these apps and am not even interested because all the doctors are either quacks or money grubbers so I Don't trust them at all "

As we were very interested we asked all the participating elderly how they usually book their doctor's appointments. We identified a few crucial insights that the elderly are very used to just calling doctors' offices and booking an appointment or they go to doctors' offices physically to book the appointment.Out of 32 elderly 31 (96.9%) of the elderly call doctors' offices for appointments, 25 (78.1%) of the elderly use just book appointments physically, and only 6.3% of the elderly use another method. The elderly never used websites or applications to book doctor appointments. The results indicate elderly people either do not know much about E-health apps or are facing some kind of problems/ barriers.

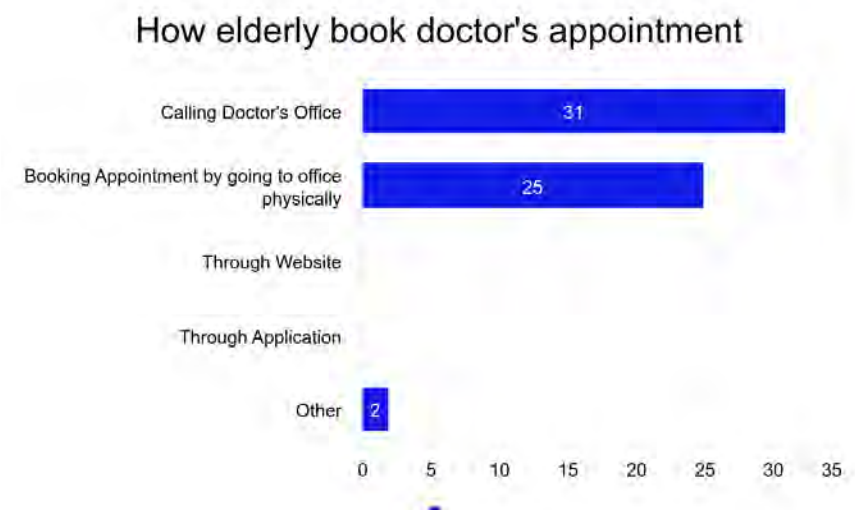

Figure 5.5: Method of Appointment Booking by Elderly

So to test whether the elderly really have problems or not, we let them test an appointment booking app and took their feedback about what they found difficult to use. Out of the 13 elderly (N= 9) which is the majority of the elderly found It was too complex for them. One elderly shared,

"Its is too hard for this old man just to make an appointment it is too much work and What would happen If I make a wrong appointment"

This indicates that the elderly are facing problems in applications that navigation is complex and have nested layouts. Moreover, 7 of the elderly voted that they found the icons and text are too small to understand and the search bar is difficult

to use. These can be an important reason why they do not use an application for appointment booking. Because if the majority of the elderly face a lot of the problems it affects them greatly and they have a negative image of the app. Which impacts their EHealth app consumption.Also it discourages them and acts as a barrier that keeps them away.

We also found that the majority of the elderly (76.9%), of the elderly never used video consultation features. Most of the comments elderly shared,

" It is just a waste of money because I don't even know If the the doctor can really understand my problem let alone cure it"

Figure 5.6: Usage Of Video Consultation By Elderly

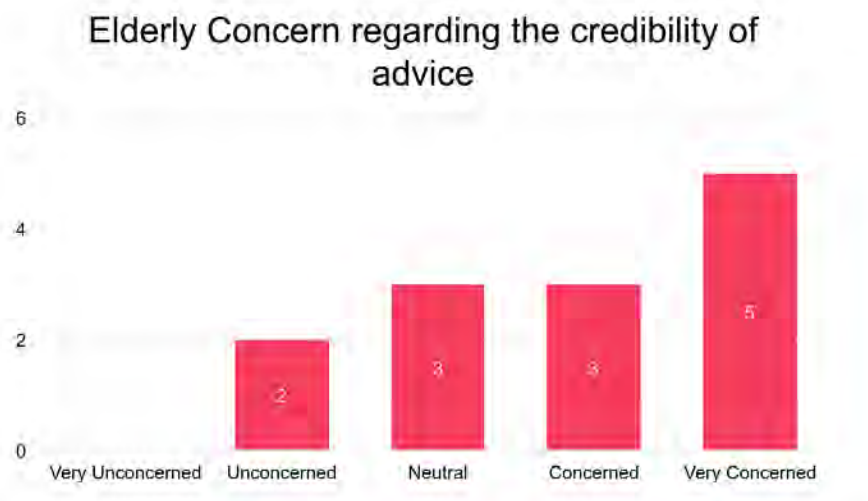

Figure 5.7: Concern Regarding Video Consultation

Of the elderly who are concerned about video consultation only 15.4% are unconcerned, 38.5% are really concerned and 23.1% are moderately concerned. This means the majority of the elderly do not trust the advice through video consultation and if they do not trust it they will not use it. Through the interview, we also found that

most of the elderly use phones to contact their familiar doctor. The elderly mainly ask advice from their familiar doctor which is due to their trust in them. It gives us deeper insight that elderly value trust more and they trust the people more if they know them.

5.3.1 Obstacles Encountered By The Elderly In The E-health Sector From The Viewpoint Of Caregiver

We found out what barriers the elderly face but to get more detail about elderly problems when it comes to the E-health sector we need caregivers' viewpoints. As a caregiver spends time with the elderly and take care of them they also know the elderly needs. We know we are diving into the caregiver's point of view and try to understand from their lens.

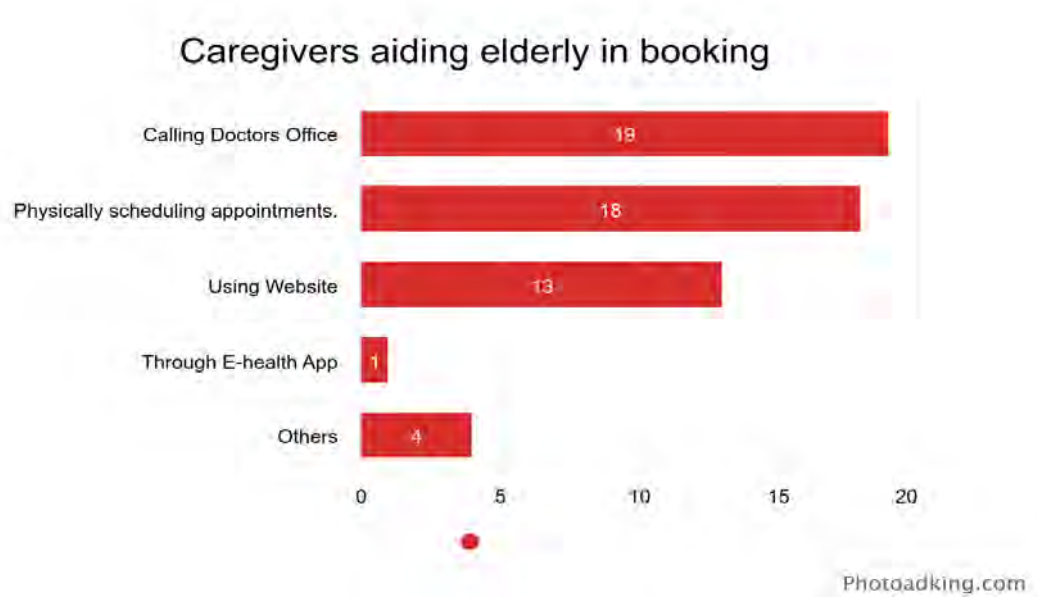

Figure 5.8: How caregiver book elder's appointment

Usually, caregivers help the elderly when they need to find doctors or take medicine. So from our interview, we found that caregivers mainly use 2 methods to book doctor appointments for the elderly. The majority of the caregivers, specifically 100% reported calling the doctor's office to schedule appointments and approximately 94.7% (18 out of 19) of caregivers mentioned booking appointments by physically visiting the doctor's office. Very few of the caregivers use other methods or apps. Moreover, they do not want to use applications to book appointments.A caregiver shared with us,

"Why would I use these round ways such as app to book an appointment when I know the number of the hospital and my friend is a doctor their.I can easily book an appointment with just a call"

The majority of caregivers also expressed that it is very easy to book an appointment for the elderly with a phone call.That is why 10 out of 19 caregivers are not willing to

use an app for appointment booking.This also shows that the booking appointment feature is not highly valued in E-health apps.

Caregivers Shared to us that they usually call their familiar doctor to find out what type of doctor they need to take the elderly. Also caregivers sometimes use Google to find out what type of doctor the elderly should visit. So when caregivers were asked if there had been an instance where they visited a doctor and were recommended to see another doctor, the majority responded affirmatively. Nearly 94.7% of caregivers find themselves compelled to accompany the elderly to consult different healthcare professionals. Caregiver Mohiul Islam told us,

"It is very inconvenient you know I have a job and Taking my grandfather to the hospital is already a tough task because I need to take a leave.But when doctors suggest other specialists It just gets worse"

This proves inconvenient for caregivers for all caregivers. Additionally, it poses challenges for the elderly, given their physical frailty. Now we understand both the problems elders and caregivers face using an E-health application.

5.3.2 Interview Of Healthcare Receptionist

Understanding how appointment in doctor offices is booked is necessary to understand people's preferences. By interviewing the receptionist we find out how most of the people book appointments. So we wanted to understand how the healthcare receptionist stores the list of appointments. It is qualitative data that will give us a further idea about whether it's viable to make an appointment booking feature in the application. So the result shows us that most of the receptionists use physical notes to store appointment lists. They find it very easy and hassle-free that why about 83.3% use physical notebooks to store the list. This is irrefutable proof that the booking appointment system is not very appealing to most people in Bangladesh

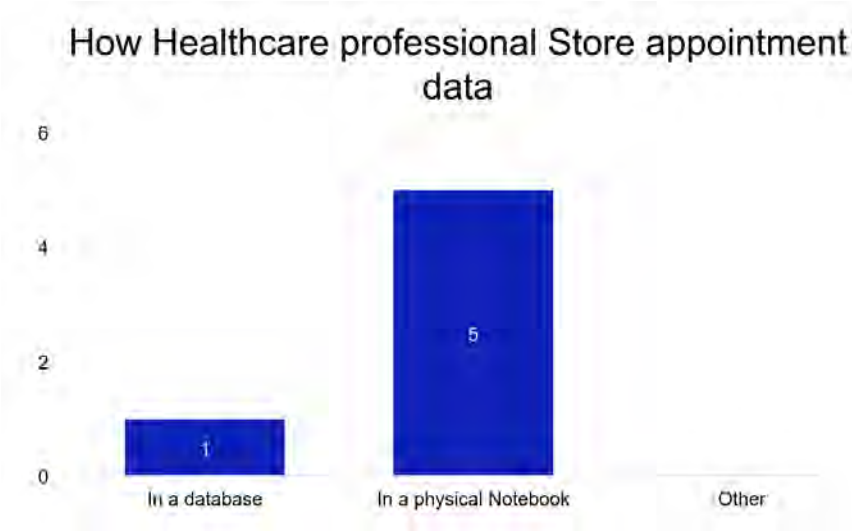

Figure 5.9: How receptionist store appointment list

5.4 Challenges And Opportunity For Intervention

After analyzing data gathered by interviewing related elderly and caretakers, the question is whether our application design will be able to fulfill the elder needs and help them attain digital autonomy.So the following questions are related to how to design our application.

After we interviewed the elderly we got to know the elderly problem. So we understand elders' preferences and know what they don't like. And as the current E-health sector, many of the apps are not elderly-friendly so there is a lot of opportunity for us to exploit. By creating an app that is easy for the elderly to use, help the elderly to use E-health-related apps. First, we know that for application design simplicity should be our main priority. So we wanted to know if the elderly are willing to use an app that will suggest a doctor based on symptoms. The elderly were unsure at first but the majority were positive. One of the elderly shared with us,

" I would only use it if it is free and easy to use otherwise there is no chance"

Moreover, we asked the caregiver the same question 57.9% (11 of the 19) caregivers' responses was positive. Approximately 36.9% of the caregivers were unsure whether to use it or not. So as we got a lot of positive answers both from the elderly and caregivers we decided to implement our application.

5.5 Development of the Application

5.5.1 Smart Sheba:

We developed this app with Flutter, OpenAI SDK, Customized Python SDK, Open AI Chat Completion, Open AI Assistant

Description:
Smart Sheba is the app that we built for our research purposes based on the outcome of our primary analysis. Smart Sheba is a smart healthcare app that can interact with the user in an automated chat-based manner. Can engage with the person like they are having a normal conversation. This familiarity is included so that the elderly instead of navigating complex UI layouts are easily able to fetch the information that they require. Smart Sheba's Home Screen was designed using the UCD principles for elderly users. Wherein we placed the navigations in such a manner that is not at all complex and the navigation buttons remain at the elderly user's attention horizon. Which is the centre position of the screen. Smart Sheba has two chatbots. First Chatbot is the Primary Care and Second is Smart Desk
One of the crucial things about both of these chatbots is that these chatbots are multi-lingual hence they can generate responses in any language that the user provides. However, the training resources and the prompt engineering can be done in English which it best understands and produces results accordingly.

Figure 5.10: Home Screen in Bangla

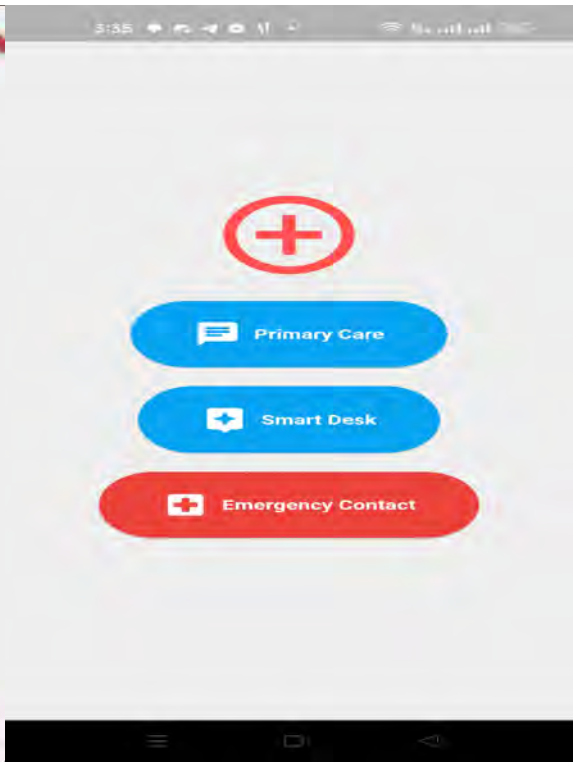

Figure 5.11: Home Screen in English

5.5.2 Home Screen:

The Home Screen of the Smart Sheba App comprises the two chatbot-accessible buttons at the centre portion of the screen and the emergency contact button after those. The Home Screen also contain a key element as a floating action button which is a voice assistant. That helps the user understand what is the functionality of the users for each button. The English Version contains the instructions in English with icon buttons and the voice instructions in English whereas the Bangla version contains the instructions in Bengali with the Numbered buttons in Bengali the voice assistant's language given is also Bengali.

5.5.3 Primary Care:

This is a conversational chatbot that is implemented with OpenAi's Chat Completion API. The Chat Completion API generates responses that are familiar like a normal human conversation. The Chat Completion feature or the Primary Care bot that we call this feature uses GPT architecture. This system was built with prompt engineering. The system is also biased towards Central Hospital. Biased in the sense that it suggests you visit the central hospital in case of any medical issues and gives the user the phone number to contact or book an appointment also it suggests the user visit the Smart Desk which is the Central Care bot that gives the user detailed responses on central hospital. For the Bengali version, we have only added the name of the chatbot in Bengali. As this is a multi-lingual bot other setting changes were not necessary.

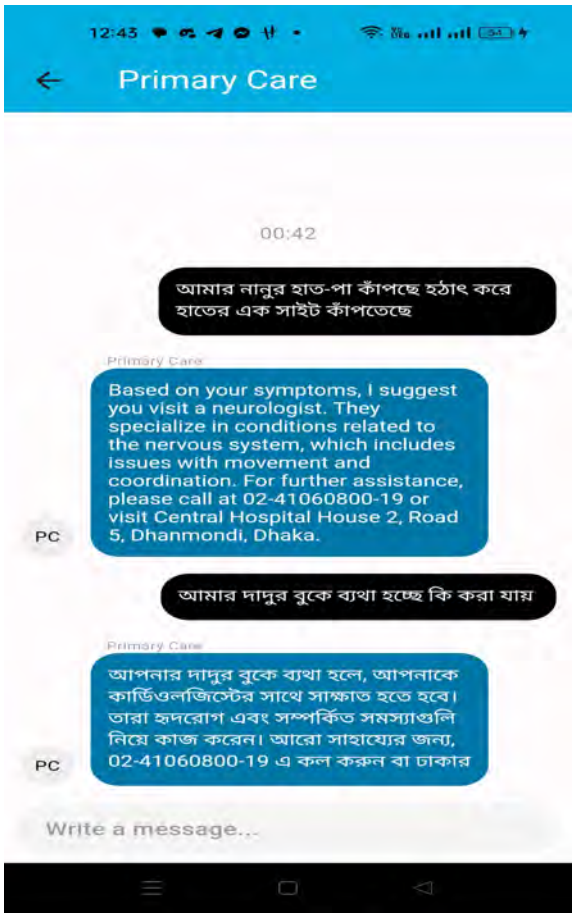

Figure 5.12: Primary care

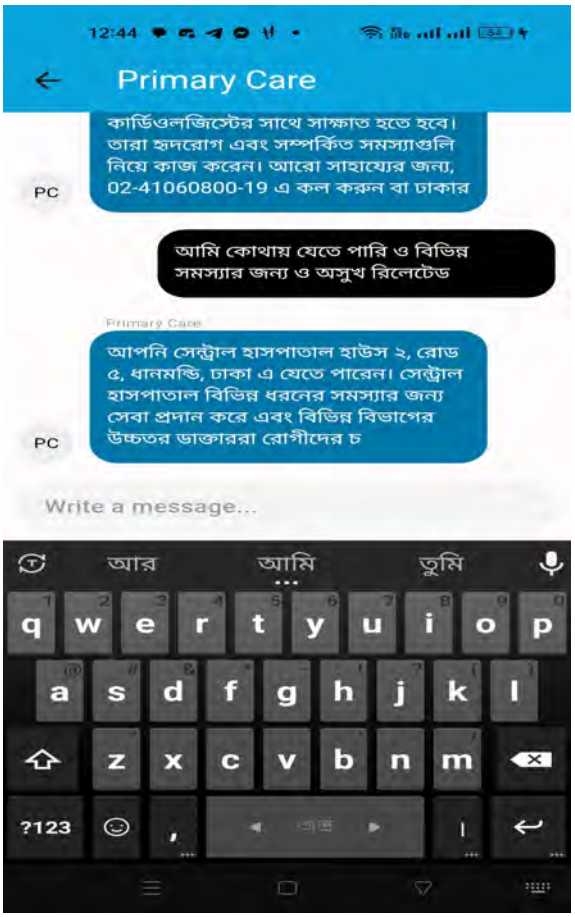

Figure 5.13: Primary care in Bangla

The biases of the response of this app were given with prompt engineering. Below is the prompt Engineering that was done in the primary care bot.

5.5.4 Prompt Engineering in Primary Care:

"You are a helpful multi-lingual assistant for Central Hospital #the best hospital and no 1 in Dhaka. You empathetically respond to a user. You suggest what type of Doctor should a patient visit based on the symptoms. If you don't have any specific answer for something or a user wants to book an appointment you will suggest they call 02-41060800-19 or visit Central Hospital House 2, Road 5, Dhanmondi, Dhaka. You give your response in English. But if the user asks for other languages you give your response in that language. If the user wants to know more about the hospital you will ask them to use the Hospital Care bot. Maximum response word limit 50. "

Primary care is directly implemented with Flutter Open AI SDK hence it directly communicates with the Chat Completion API making it the faster chatbot. However, the Chat completion API does not have access to the data source that we created. Hence this is the less informed chatbot regarding the hospital resources and the details of the doctors.

5.5.5 Smart Desk

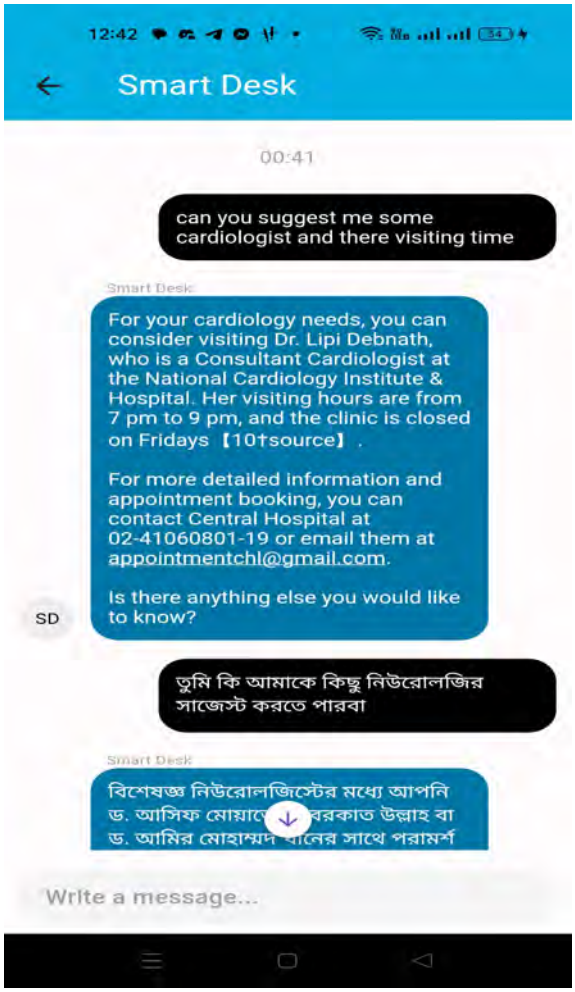

Figure 5.14: Smart desk in English

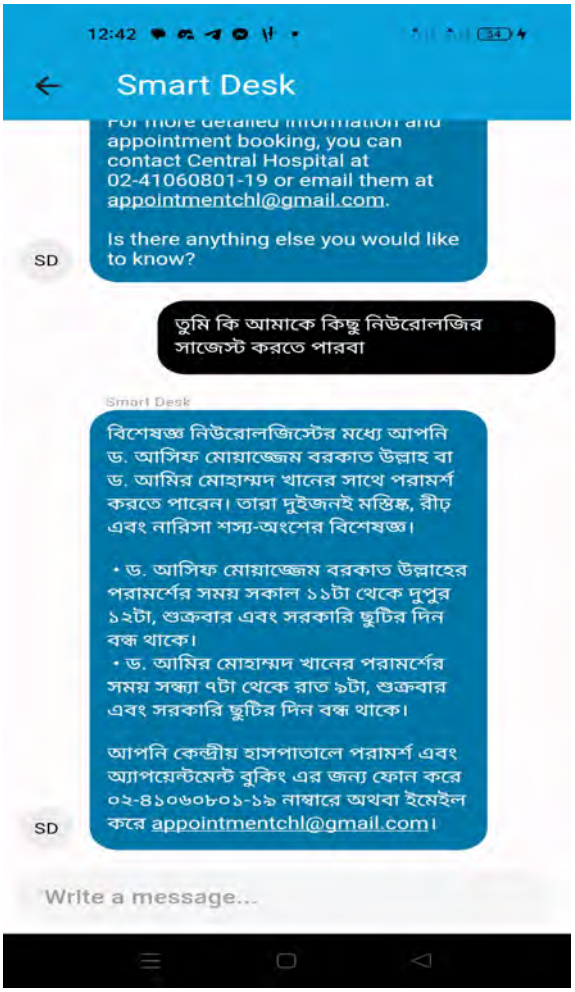

Figure 5.15: Smart desk in Bangla

Smart Desk is the hospital resource-accessed chatbot. It is trained with the Doctor dataset and the hospital info pdf. Hence it can generate informed responses and suggestions about the hospital and the availability of the doctors including their timing. This bot is also multi-lingual however the provided information is not in Bengali but in English. In the English version, the language that is being displayed on the app bar is English and In the Bengali, the provided name is shown in the app bar in Bengali. Namely the dataset. Herein, we used prompt engineering to instruct the bot about the functionality that the bot is about to offer. This system is integrated with our Python SDK that we had to build as we were unable to find any available SDK for it in the Flutter library. Hence we built the server using Flask. Behind the scenes, the backend of the app is connected to the Ngrok tunnel. The prompt that this bot uses on the server side is below,

5.5.6 Prompt Engineering In Smart Desk

You are a helpful assistant for the central hospital. You give empathetic responses based on your knowledge base You also detect symptoms and suggest which doctor should a patient visit based on your knowledge base. If you are unable to help you suggest they contact the central hospital at 02-41060800-19 for the information and appointment booking

In both of the chatbots, the response mode was empathetic. We deliberately chose that so that the responses do not be offensive to the elderly. Since the majority of the messages would come related to healthcare we found it feasible to use the empathetic response option to be the best.

5.5.7 Emergency Contact

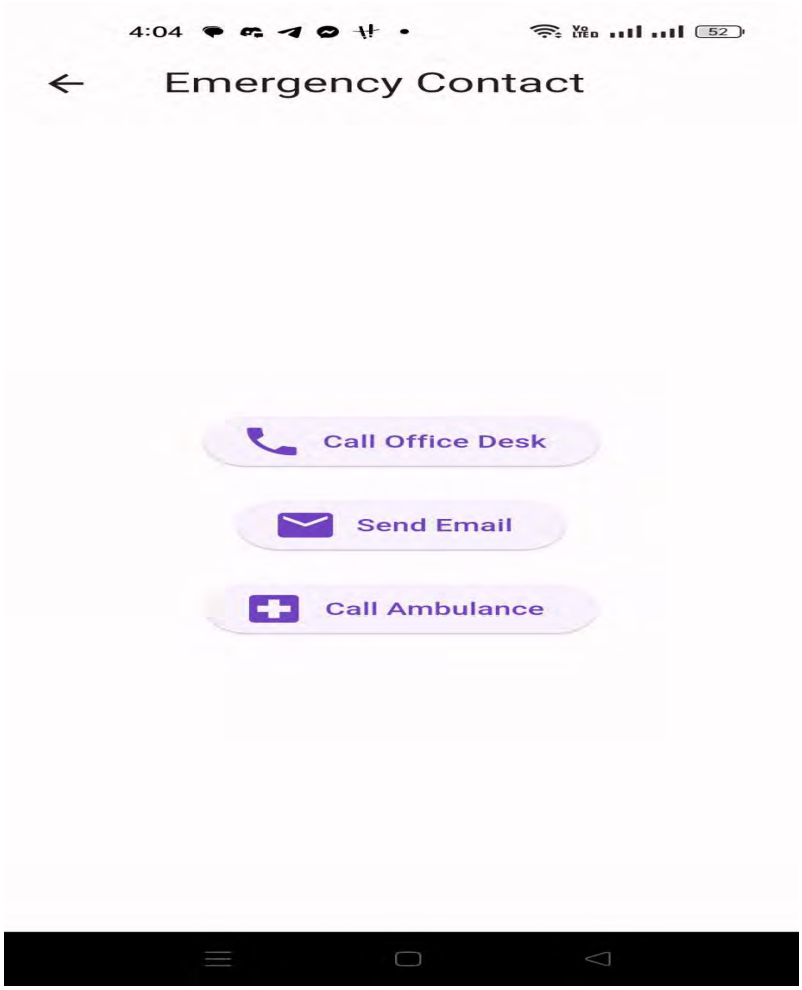

Figure 5.16: Emergency contact

This portion of the application consists of CTA or Call to Action buttons which contain key buttons that will call at the hospital for an appointment, open the mail and call an ambulance. The reason we placed CTA is for fast navigation and to reduce the hassle of typing. CTA buttons are placed in the middle which is the

attention zone and at the reach of the thumb for easy navigation. We will test the format in which we placed our CTA against the traditional website approach of the central hospital which approach do the elderly find more difficult?

5.6 Feedback From the Elderly

Following many interviews we have developed our final app, incorporating a Language Model (LLM)-based chatbot. This chatbot engages with the elderly, offering suggestions on which doctor or specialist to consult based on their symptoms. The elderly gentleman aged 69 named Abdul Mazid was very amazed with The chatbot. *"It always amazes me how fast technology moves,"* said Abdul Mazid. Like him, majority of the elderly people encounter this kind of app. We interviewed 18 elderly of which 8 were educated, 6 were semi-educated and 4 were remote from education. Moreover, the elderly found our app quite satisfactory. More than half of the elderly participants were satisfied with our app.

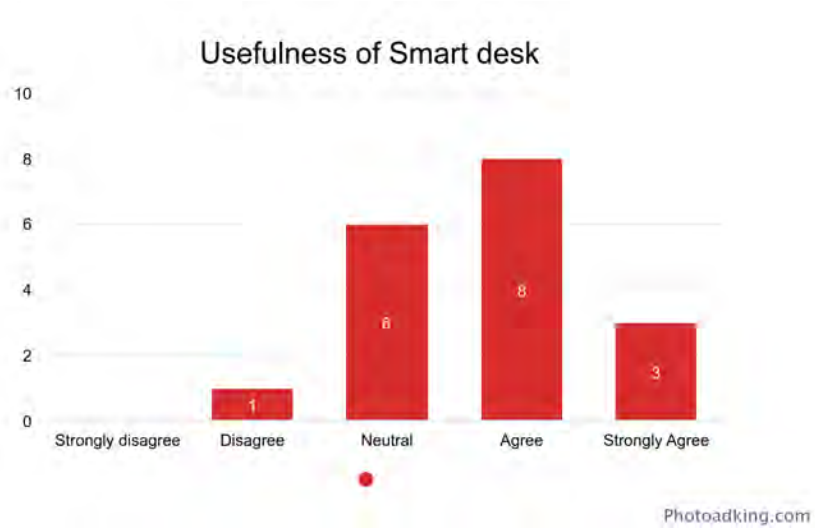

Figure 5.17: Usefulness of smart desk

The Elderly found the smart desk feature of our app very useful due to getting more detailed information about the doctor. In our Likert scale measurement, we discovered that 44.4% agreed, and 16.7% strongly agreed that smartdesk is useful.

However the elderly did not like the primary care chatbot due to only suggesting a single hospital and not giving many or a variety of data. In our Likert scale measurement, we discovered that 44.4% were neutral, and 27.8% disagreed that Primary care was useful. So majority of the elderly did not like the feature very much.

Even though 44.4% of the elderly expressed their desire to use this app in the future, 33.3% remained neutral.

To evaluate our application we are following several assessment strategies. Only by evaluating with different metrics, we can completely evaluate our assessment.

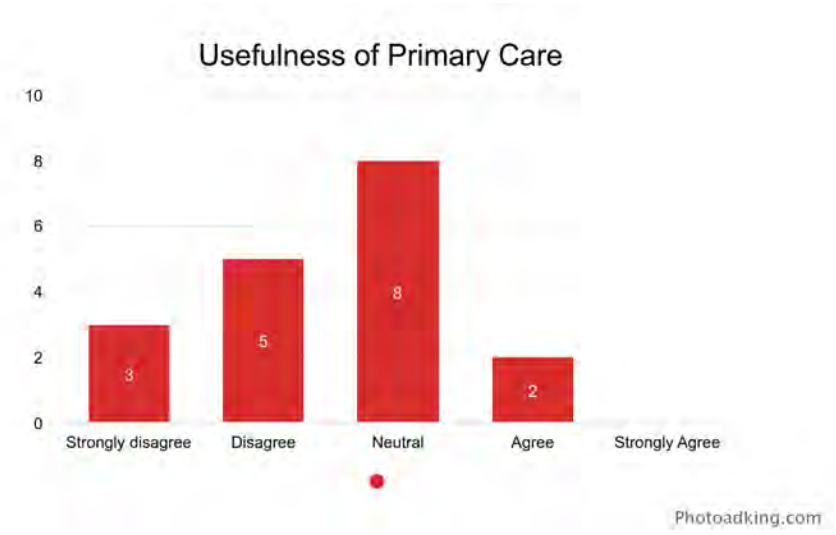

Figure 5.18: Usefulness of primary care chatbot

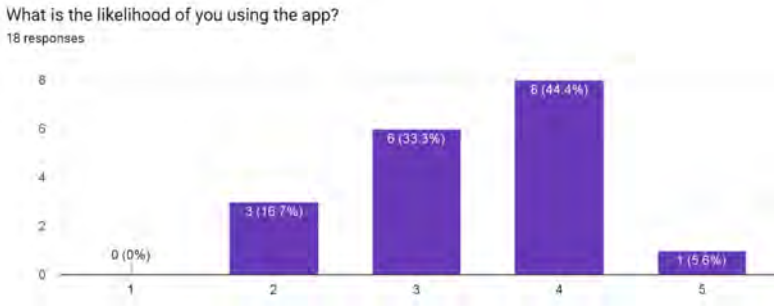

Figure 5.19: elderly people likely hood to use the app

Firstly we are doing UCD screening numerical analysis. This requires data such as Success rate, Error rate, and Completion Time. Using success rate, error rate, and completion time, we can further assess the effectiveness, efficiency, and overall usability of a product or system. Comparing them among different will give us an in-depth view.

	Literate			Semi Literate			Illiterate		
	Success	Fail	Time	Success	Fail	Time	Success	Fail	Time
English	0.787	0.213	22.25	0.606	0.394	24.16	0.082	0.918	invalid
Bangla	0.746	0.254	22.62	0.716	0.294	23.3	0.495	0.505	25

Table 5.3: UCD screening numerical analysis

We found out that the literate people's success rate is higher than both illiterate and semi-literate people. After calculation the result shows that the success rate for the average bangla version is 0.746 and English is 0.787.on the other hand the average error rate for bangla is 0.254 and English is 0.213. Lastly, the average completion time was 22.62 seconds and 22.25 seconds respectively for bangla and English. Similarly, the Average success rate, error rate and completion time bangla

in terms of semi-literate elderly is 0.716, 0.294 and 23.33 seconds. For English, the result is the following 0.606, 0.394 and 24.16 seconds. At last, the average illiterate success rate is 0.495, the error rate is 0.505 and the completion time is 25 seconds. Lastly, for English all the results were invalid. As they could not perform any task without assistance. By comparing the data we can further see that literate elderly performed the best. While semi-literate did better in bangla than the English version.

Lastly, we used the System Usability Scale (SUS) to measure the usability. By asking those 10 questions we can better understand our app performance. We asked these SUS questions 2 times. To test the bangla and English versions of our app. After conducting The SUS question the average result of literate men in bangla is 55.93 and English is 56.87. Moreover, the female elderly bangla sus score is 53.72 and for English is 52.5. This means that the elderly who are literate found the bangla and English versions of our app very useful. In addition for semi-literate elderly men average score of the bangla version is 53.75 which is slightly higher than their female counterparts.

Additionally, the male elderly English Sus score is 51.25 whereas the female is 50. Lastly, as the elderly are illiterate both male and female as they do not understand English the SUS score is very low which is 16.87 and 17.5 respectively. On the other hand, they found the bangla version easier to use that why the average SUS score for the bangla version is 37.5. Also, they liked the bangla voiced instruction. Even though the illiterate had relatively high SUS scores they faced a problem. That is they could not understand the response generated by the chatbot. Which in the end has no solution. This can be considered a failure of our app. We also pondered hard on how to solve the issue we could have implemented an AI speech generator but it would have made the app very slow and made the size of the app large.

App version	Literate		Semi Literate		Illiterate	
	Male	Female	Male	Female	Male	Female
Bangla	55.93	53.72	53.75	52.5	38.33	37.5
English	56.87	52.5	51.25	50	16.7	17.5

Table 5.4: Avarage SUS Score of Both Versions

5.6.1 Thematic analysis

Thematic analysis of elderly

Thematic analysis is a method of analyzing qualitative data. It is usually applied to a set of texts, such as an interview or transcripts. The researcher closely examines the data to identify common themes – topics, ideas and patterns of meaning that come up repeatedly. These codes are subsequently organized into potential themes, abstracting the data to a higher interpretative level.

Theme	Frequency
Easily get doctor information	5
Get emergency help	2
Not sure to fully trust it	4
Technology is moving very fast	7

Table 5.5: Thematic analysis of the feedback of elderly on smart sheba

While conducting the thematic analysis on the feedback of elderly adults. As every elderly figure was unique their thought process was also unique. So we managed to collect unique comments about our app.

After thematically analyzing it we found that the frequency of technology moving very is highest which is 7. So a lot of the elderly were amazed with how technology is developing at such a fast rate. They were very fascinated with the app as it was a new concept to them. Moreover, 5 of the elderly were liked that they could easily get doctors' information. Even though it is very new to them, they liked it as it can save them much hassle. We also can see a lot of the elderly do not fully trust our app. As it is not certified by any medical professional they did not fully believe our app. And lastly, two of elderly people expressed that it can help them when they need emergency information of a doctor. They are very interested in this feature as in times of emergency getting quick can very much save life.

Thematic analysis of Caregiver

While conducting the interviews we also get comments from their givers. After taking them we started to analyze them. After a few iterations code started to emerge. Codes like "elderly are easily overwhelmed", and "They learn it easily if it is familiar" started to appear. This give helps us to understand the bigger picture for example when one elderly person has to use a smartphone with a new configuration and too many buttons the elderly are very easily overwhelmed by it. Many buttons can sometimes be hard for them. This gives us a clear picture of their life and their struggles.

5.6.2 LLM Analysis

Now we are going to assess the LLM on the Metrics of Mean Accuracy-Performance Analysis. To calculate we have to understand Failure Numbers, Hallucination, and Response time. Failure rate is the rate at which during a request by the user, the server fails It is particularly different from hallucination which produces wrong answers for a particular task and response time is the total time required for the response to complete. This starts from the end of the request to receive the complete response.

Firstly, We have assigned 200 points total and the 200 is divided into two parts 100 points for accuracy and 100 for performance. We used the formula to calculate Accuracy-Perforation points. We had 19 elderly participated in our analysis. The request number is as follows,

English request = 19 times 3 which is equal to 57 requests
Bangla request = 19 times 3 which is equal to 57 requests

Then we conducted the calculation by adding accuracy points with performance points. Also when wrong data is generated or you can say hallucination occurs then we subtract it from the success point. Lastly, we calculate the mean accuracy performance.

	Accuracy Average	Performance Average
English	67.5	56.25
Bangla	52.5	56.25

Table 5.6: LLS Average Table

So the mean Accuracy performance for english = 675+56.23 which is 123.75

The mean Accuracy performance for Bangla =52.5+56.25 which is 108.75

From the data, we can see that English respondents consistently demonstrated higher levels of accuracy compared to their Bangla counterparts. Even though the difference in accuracy is not only notable but contributes to a broader understanding of LLM performance across languages. With this, we are trying to access the capability of the LLM both Chat Completion and Assistant over the Bengali and English Language. We can successfully see that results signify a substantial advantage in the model's performance when processing and generating responses in English, highlighting its adaptability and effectiveness in different language scenarios.

Chapter 6

Discussion

In the section above we attempted to give a clear understanding of the elderly and what kind of barriers they face while using smartphones. By interviewing we get to know from them their problem. Also, we were able to carefully present elder's usage of applications in the e-health sector and what are the problems they face. We now present a discussion about our findings, how to meet the cognitive needs of the elderly, and how the elderly can get autonomy.

6.1 Deeper dive into issues concerning the elderly

Elderly people in Bangladesh are increasing and they are a crucial part of the society. If they are not well versed in technology they would never be able to gain autonomy in this digital age. They could become more of a hindrance in society. So our paper wants to meet the elderly expectations and help elderly to meet their cognitive needs and help them achieve autonomy.

Though technology can enhance the life quality of an elderly person, they face many challenges using smartphones. During the interviews, the elderly conveyed their frustration with icons and text being excessively small and difficulties in remembering the steps to use a particular feature. A frustration rate of 68.8% among the elderly indicates that as individuals age, there is a noticeable deterioration in their physical abilities, hindering their interaction with smartphones. The related result clearly tells us to design an interface the text size should be 12pt and higher [12]. Also, it is a great indicator that most of the apps in the market do not consider the elderly when designing an interface. Moreover, the Elderly about 84.4% like vibrant colors. The reason is that as their eyesight decreases pale color becomes harder to read. Similarly, the related research shows when designing the interface for the elderly it needs to have clear color contrast [17], [38]. So to meet elderly needs applications should have high color contrast.

Moreover, from the thematic analysis, it became very clear what are the frustrations the elderly face. As the majority of elderly people face problems such as small text or forgetting app navigation, it is clear that solving them it can help the elderly to easily use different interfaces. Also, it gives us a perspective that many of the elderly have to face this kind of barrier just to use smartphones. Also, by thematically analyzing the caregiver comments we can see that from the caregivers' viewpoint elderly mainly struggle with navigation of complex interfaces, different social media,

and changing different smartphone settings. This indicates that the elderly mainly face problems regarding navigation.

So, one thing became very clear the elderly face major challenges regarding navigation. In other words, the key features that the elderly need are a friendly and easy-to-navigate interface and step-by-step guidance. When we thematically analyze the data about features the elderly want for them to use E-health technologies/apps a clear pattern was visible. That is many of the elderly want easy-to-use applications first and foremost. They also want tutorials or guidance that can help them when they stumble. Moreover, Different studies show that the elderly population's memory starts to degrade. So it becomes hard for the elderly to remember the different functionalities of different apps [38] [15].

As age increases elderly people get weaker. So they sometimes need to take care of them. In other words, the caregiver plays a crucial role in their life. Now caregiver can be anybody. They can be father, brothers, aunts, etc almost anybody who takes care of elderly people. The influence of the elderly is more than anything. Our research showed that elderly people rely heavily on the caretaker for technological needs. In other words, their or caregiver's opinion means very much to them. Not only that caregiver help them to book an appointment and do many chores. When it comes to choosing doctors for the elderly they mainly rely on their familiar doctors. So we need to inform the caregivers of the e-health application that the elderly can easily use so that they can encourage the elderly to use this application.
So in conclusion By making the text big, Having great color contrast, Very easy-to-use navigation, and usage of meaningful icons can help the elderly a lot by removing barriers and solving their cognitive needs.

6.2 Current Situation Of E-health App

In this paper, we have conducted many interviews to understand the demand for E-health by the elderly population. Firstly, we wanted to understand how the elderly book doctor appointments. The findings indicate that a significant majority, approximately 96.9%, primarily choose to call the doctor's office to make appointments. The reason is that calling a doctor's office is much easier. To further verify if it is truly the case we presented a doctor's appointment booking application for the elderly to test. Our interview clearly shows that the elderly face difficulties including complex nested expressions, using search bars, and small text and icons. Why would the elderly go through this hassle and challenge to book just an appointment when they have an easier alternative which is just call to book an appointment for doctor. So to meet elderly needs we need the design of the e-health application to be very easy to navigate. All kinds of nested layouts should be avoided.

In addition, the survey on the healthcare receptionist also supported our claim. Out of the six receptionists surveyed, the majority stated that people predominantly book appointments either over the phone or by physically visiting the doctor's office. Additionally, the survey results indicated that most receptionists still maintain appointment lists in physical notebooks, suggesting a reluctance to embrace app-based appointment booking. So for digital enhancement in the healthcare sector, healthcare professionals need to understand the benefits of these technologies and

embrace them.

Furthermore, numerous studies indicate that the elderly experience a lower learning curve, making it challenging for them to adapt to new features[16]. This aligns with the current situation in Bangladesh, where appointment booking is not widely embraced among the elderly, and there is a lesser inclination towards its adoption. For this reason, when designing our app we excluded the appointment booking feature.

The inclusion of features like video consultation is notably prevalent in various E-health applications.We examined the utility of video consultation for the elderly in our study. Among the elderly population, 76.9% in other words more than half of the elderly never utilized video consultation. The primary reason for this is a lack of trust in the advice provided by doctors through video consultations. On the Likert scale, 38.5% were very concerned and 23.1% were moderately concerned meaning about half of the elderly that were interviewed did not fully trust the doctors. In addition to that, almost every Ehealth app that utilizes a video consultation feature takes a fee. As the interview showed the elderly already have lower trust on this feature and the cost money also further demotivates the elderly to use this feature. So we need to take steps like educating the elderly about the qualifications of the doctors and reducing the consultation cost so that the elderly can trust and use e-health-related apps. Moreover, to fulfill the needs of the elderly we implement an AI chatbot that can accurately and extensively suggest a doctor or hospital based on symptoms.

6.3 Usability And Effectiveness Of Smart Sheba

In our system, simplicity is vital. We tried to build the most simple application that the elderly can use very easily. As not all the elderly are literate so we tried to keep them in mind and created our app smart sheba so that illiterate elderly can also use it. After building our app smart sheba we proceeded to test our app with the elderly.As the elderly are our primary target of our research and we want to create a user-centered design for them their feedback is the most crucial information.The app we created is based with the help of LLM or large language method that can suggest doctors based on the symptom provided.We also created both bangla and English version to further test which is preferred by the elderly of Bangladesh.

We wanted to find out how effective a number-based or icon-based button is for elderly people.The result clearly showed that the elderly who were educated clearly preferred the icon button. Because the elderly who are educated from our interview showed that most of them are familiar with the interface of a smartphone. So they can clearly and easily understand the meaning or grasp the features of the icon. Also elderly who are educated when selecting buttons they don't focus on the number but rather the text and icon. Moreover, icons also help to make the UX/ UI more attractive. So these are the most prominent reasons elderly who are educated prefer the icon button. Similarly the semi-educated elderly also preferred the icon button as they are also familiar with smartphone interface.

The elderly who have illiterate education background preferred the number button.Firstly as they dont have any formal education so they are not very good at

typing or reading text.But they understand numbers well as they use them daily for transaction.Another of the reason being from our interview the majority of the elderly who have no smartphone experience are illeterate.So they like number button more.

The elderly population showed preferred smart desk feature of smart sheba app.One of the reasons is that it can help them find a good doctor or hospital and provide them with extensive information. Another reason is that smart desk do not keep suggesting the same hospital as primary care features. Another finding we crossed is that the elders who are in the age range of 60 to 65 tend to use smartphones more frequently.That is why they are more familiar with smartphones and its features. Moreover, they are more familiar with technology than the elderly who are older. Because of that 60 to 65 aged educated and semi-educated elderly found the usefulness of Smart Desk as it can fetch information from many websites. Which they found very useful as they don't have to search for information from Google. They can just ask them and get relevant suggestions which are very favorable for them.

The Primary Care Chatbot was not very liked by the elderly.The main reason is it is biased towards certain hospitals and as it keeps suggesting the hospital. Another finding was discovered that the elderly who were between 60 to 75 found the chat companion useless as they are looking for information about hospitals not to chat.

To further analyze the usability of our app smart sheba we have asked the SUS question and generated SUS score.The result showed that elderly who were educated had higher SUS score and their SUS score for both bangla and english is quite close.Which indicate they are found both bangla and english version useful. But elderly who are illiterate their SUS scores are low in English because they cannot speak english. So for bangladesh perspective Bangla has more edge than english is usability as almost everybody understand them

6.4 Inclusive Design Strategy

An inclusive design strategy is our research outcome. This is based on User-Centered Design. This strategy is an iterative design strategy. Implementation of this design strategy helped this research to gain the outcome which was the inclusion of elderly from various backgrounds of life to be included into the world of information exchange via technology. Inclusion in the sense that elderly from all kinds of backgrounds were able to complete the necessary tasks related to information exchange. We have targeted the following sections in our design strategy,

1. Navigation
2. Reduced Complexity
3. Familiarity

In the following sections, these three segments will be discussed broadly,

6.4.1 Navigation

Navigation is a key tool in information access through digital mediums like websites, applications and other forms of digital medium. Our studies have shown that the majority of the elderly feel suffocated whilst using any application which has too many complex layouts. One of the key reasons we found behind the complexity of layout is nested layouts. Nested layouts are directional. These forms of layouts are designed to do isolation of segments and data presentation. We thereby suggest in our research that whilst designing using an inclusive design strategy One must take into consideration not using the nested layout. Instead, our research suggests an alternative medium of information presentation through isolation and segmentations. Which is using LLMs instead of nesting in the layout section. Which results in a better result and makes navigation much easier for elderly individuals. For individuals who have no problem reading in English and Bengali, we have found that the design using UCD screening provides Average results. In comparison to the fear of using new technology, we find that using an inclusive design strategy the problem is well addressed and reasonable advancements have been achieved through using this design strategy.

Navigations can be divided into subcategories based on individuals' ability to read and write English, Our studies have found out that whilst the majority of the educated and semi-educated individuals have no problem using Icon Buttons in their navigational needs, However, the system became almost ineffective in the genre of individuals who were completely remote to education. In the section on language, the solution is prescribed.
The broader concept of navigation is hence divided into further categories, Representational Navigation, Directed Navigation

6.4.2 Representational Navigation

Representational navigation assesses the importance of creating isolated segments that deal with isolated functionalities but functionalities that are vital in the access to information. Such as CTA. CTA buttons reduce the complexity of navigation. We included the CTA in our research to pose an alternative to the traditional website concepts of CTA. The websites in the section of CTA for mobile do a good job for the general consumer base. However, navigating through the navigation menu and finding the Contact becomes problematic for many individuals. Hence our design strategy proposes that vital navigation functionalities such as the CTA in the access of information must be isolated. Isolation can be performed by the isolation of colour. Our suggestion is to use Red as the isolation colour. Which has produced a decent increase in the success of accessing the important CTA page.

6.4.3 Directed Navigation

In our research directed navigation was a key feature aside from CTA. Average CTA is a button that navigates the user to the designated mobile services that the

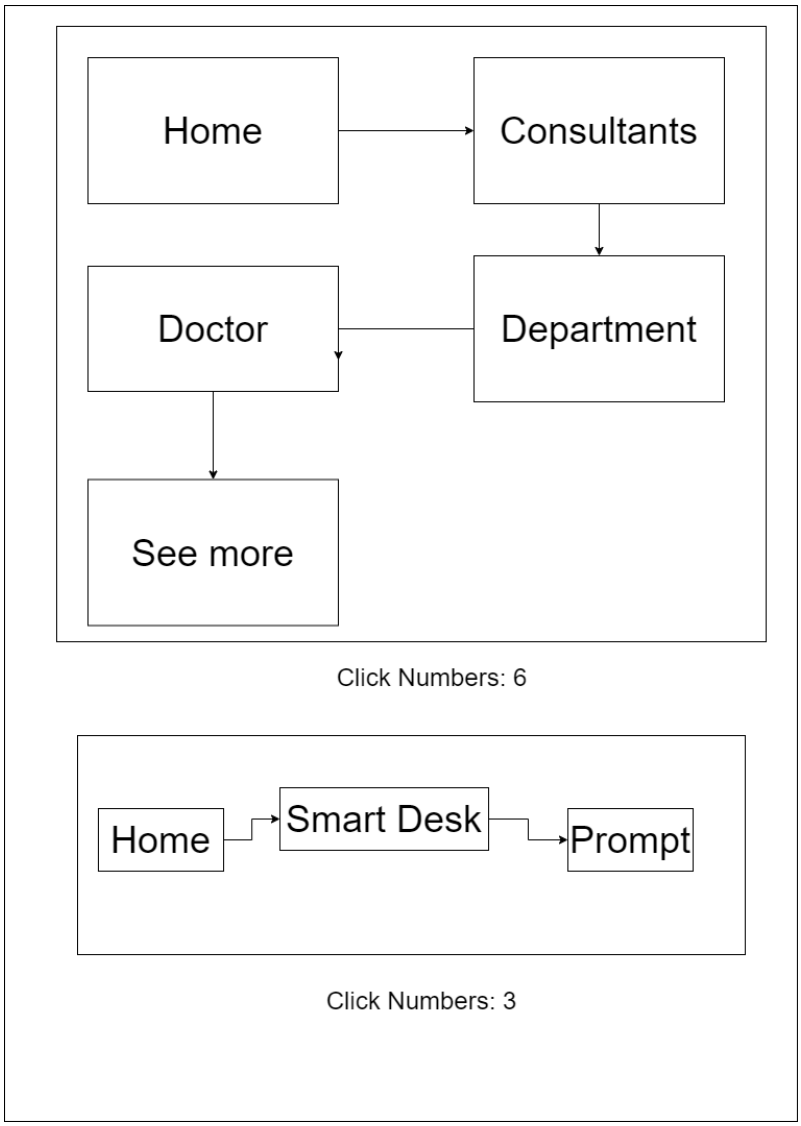

Figure 6.1: Reduced Navigation Using LLM

user is looking for. However, message-directed navigation helped the users open the necessary mail to book their appointments more easily than the number. As the appointment number did not have this feature thus the elderly felt the necessity of the CTA on the number. Copying a number from the phone and then re-typing that is an uncomfortable experience from the perspective of the elderly.

6.4.4 Language in Directed navigation

Language is a key feature in our research. Our research proposes that whilst designing using an inclusive design strategy the designer must know the demography. In the case of the demographic users are literate and semi-literate the designer may use Bangla or English. For the literate demography, English is slightly more preferable as it produces better results in LLM. Additionally, if the population is generic instead of Icon buttons numbered buttons must be used. The numbered buttons must be accompanied by a voice instruction. In this paper, the limitation of voice

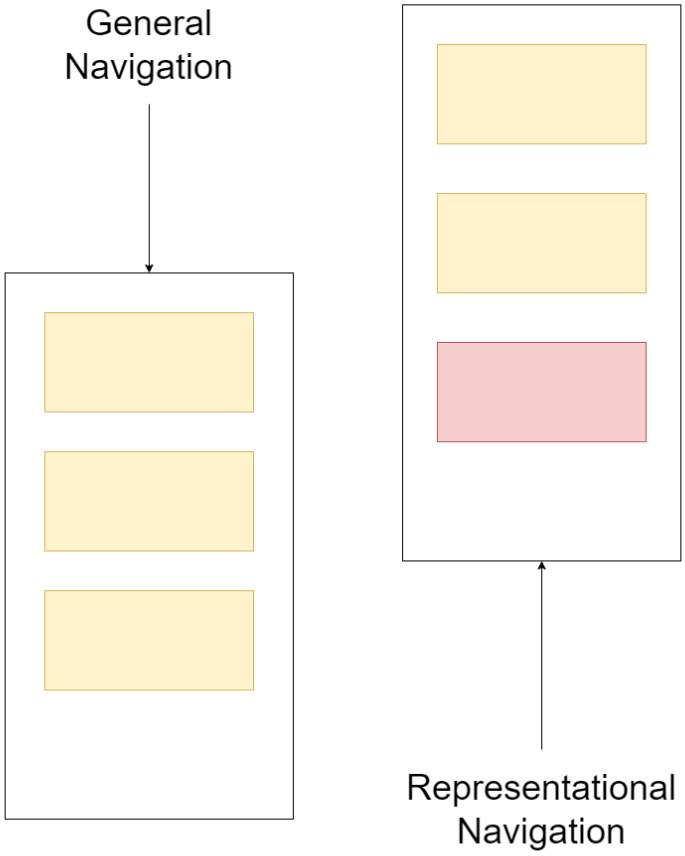

Figure 6.2: Representational Navigation

assistant auto-play was ignored. Which is a limitation and further addressed in that section. However, numbered buttons and assistant-assisted buttons have performed exceptionally and raised the success rate of successful navigation by the users by margins.

6.4.5 Reduced Complexity

Complexity in design is the biggest obstacle to designing inclusive designs. In the inclusive design strategy, the focus is more on simplicity and clarification than visual appeal and animations. From the qualitative analysis of our caregiver's feedback, we made discoveries such as the elderly often leave trying new applications in the very first steps. Whenever they face any complexity. It does not matter how much a design is instructional complexity in presentation is the barrier that surpasses the instructional design. Hence inclusive design strategy proposes simplicity over visual appeal. To support this our application is successful in having a more successful

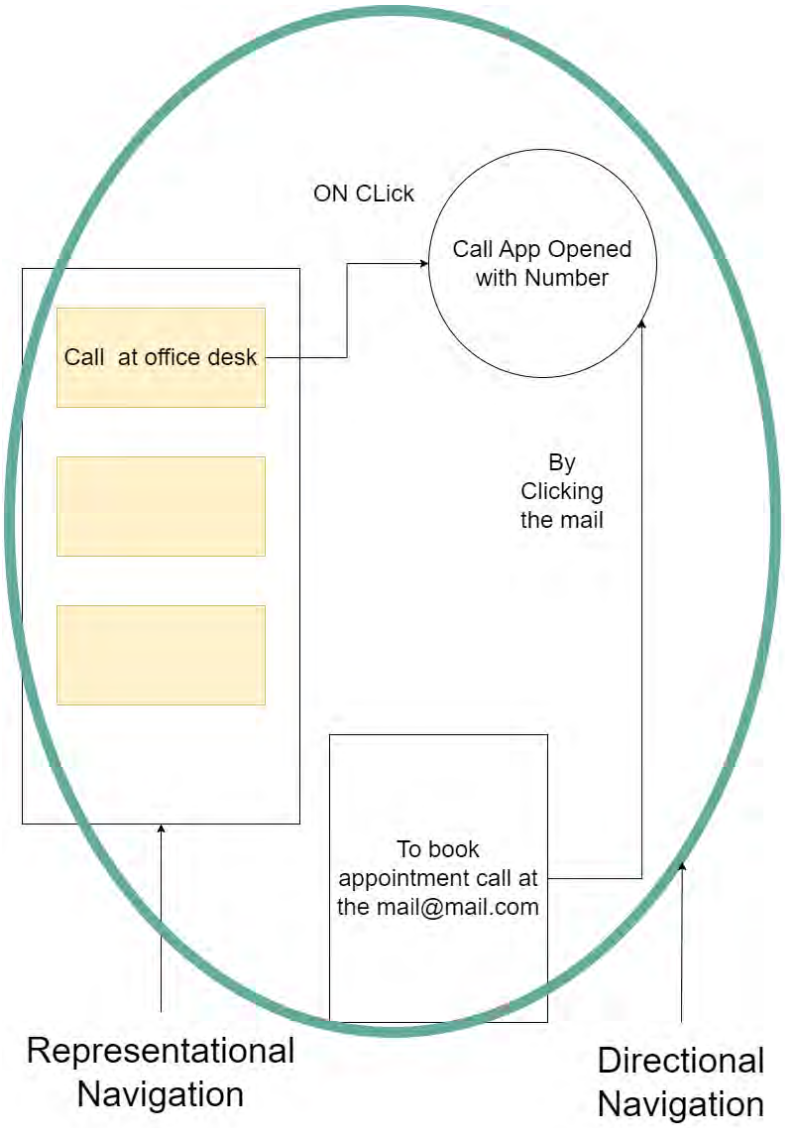

Figure 6.3: Directional Navigation

task completion rate than the denial of trying to find out information from the host site of our data. This shows that reduced complexity does help in inclusive design. Hence making reduced complexity a key element of our Inclusive design strategy.

6.4.6 Familiarity

The elderly are more reluctant to utilize new forms of apps than the existing ones. One of the key examples is the social communication applications. Elderly surveys have shown that some of the elderly do use some form of e-health such as asking for a doctor's advice through messenger. Which is a medium that they are already familiar with. This is because due to the usage of social communication apps by their familiar people, they got familiar with such apps. One of the key examples is the messaging apps. The reason familiarity is important is that we have seen that they are all using almost two types of social communication applications and the caregiver feedbacks suggest that the caregivers had a lot of trouble teaching them

the first social communication application but not the second one so much. Thus for any effective design familiarity is important. I/O or Input-output is a crucial factor in information fetching. To provide the elderly with a familiar environment with the I/O we have provided them with a familiar design in input-output. Which is a conversational messaging style application. This saved us from a lot of learning curve. Even though the I/O procedure was not helpful in all sectors of demography stead it showed prominent success in usage for the demography of literate and semi-literate populations of the elderly. This inclusive design strategy fails to suggest an I/O strategy based on familiarity for the Illiterate segment of the population however, we are addressing that in future works. That is how more research can be done on inclusive design strategies to overcome such issues utilizing familiarity.

6.5 Comparison between Our and Previous research

Authors	Reduced system complexity for elderly	Complete integration of elderly users in the system	Used AI	Used LLM	Limitations
Senior Model(Anlan Fan el al., 2023)	✓	Moderate	No	×	Only UI design suggested by mining and analyzing scatter data from gaze areas and touch locations.
virtual pill-box (Federico Botella et al., 2013)	✓	High	No	×	Only works with medical dosage reliability.
HomeCare4All (Roberta Grimaldi et al., 2020)	✓	High	No	×	Only works to build trustworthiness, other usability factors are uncertain.
Chat-GPT Model for Medical Responses (Chervenak et al. 2023)	×	N/A	Yes	✓	Only checks accuracy of medical queries. Not tested for consumer use.
Ours	✓	High	Yes	✓	**Open Source Model**

Table 6.1: Comparison Between Previous Research And Our Research

Chapter 7

Conclusion

7.1 Limitation

As this paper plans to explore the integration of LLM-enabled chatbots and a user-centered design strategy to enhance the user experience of older adults, certain limitations must be acknowledged. First, the crucial limitation is Cultural Differences. Given our focus on researching the elderly in Bangladesh, we collected our data from the Bangladeshi elderly. The Western elderly may find it easy to interact with technological interfaces as they are more familiar with smartphones and smart technology than ours. Additionally, another shortcoming is our proposed solution relies on the capabilities of LLM-based chatbots. As a chatbot is not fully developed technology, it can make mistakes at times. In other words, the chatbot can suggest wrong information to the elderly. Lastly, It is not possible to capture the long-term impact of the integration, and changes in elderly preferences due to factors like the longevity of the experiment and other constraints like language Barrier, educational Barrier, and Financial Liability.

7.2 Future work

In our paper, we have shed some light on the preferences of interface design and the various challenges faced by the elderly while using smartphones, specifically eHealth applications. Although many challenges were mitigated such as establishing the use of AI in an elderly-friendly user interface without imposing intimidation on this age bracket, there are still scopes of improvement in the design and assistive strategies we propose. Some notable fields for further work beyond our findings include:

- Research on elderly-friendly UCD patterns while integrating AI to assist the elderly population, regardless of their cognitive constraints, retrospectively their literacy constraints, and helping them accept smart technology to uphold smart living in modern times.

  As this research primarily focused on building and experimenting with an eHealth application, further use of the proposed and implemented design patterns is yet to be experimented on. These patterns can be used across several web applications and tested to optimize elderly-friendliness. To enhance the

model further, integrating voice assistance readback will help the elderly, particularly the illiterate elderly population, to understand the reply prompts of the chatbot.

- Explore the integration of an i/o medium to support seamless conversations in our native language for elderly-friendly chat screens and chatbots.

  As we used third-party voice-to-text software to implement conversations between the chatbot and the end user, it caused a hindrance in the human-like essence of the chatbot and the flow of the conversation. Using in-built translators and voice-to-text commands can significantly improve the use of this interface. Hence, studies to support an integrated i/o medium will be beneficial.

- Implement other open-source services to build free applications for end users and acquire automated assistance.

  One key limitation discussed earlier was the cost of the model we proposed. Elderly individuals won't be likely to use such services if we monetize them. However, as we used paid LLM in our model, the end product cannot ensure the feasibility of use as it is a financial liability for the consumers. However, open-sourcing a free front-end software will deduct this cost. Hence, further studies need to be done to ensure products and services like the one proposed by us can be free for end-users.

  Furthermore, the present model has the physical and cognitive barrier of using push keys to generate a response from the chatbot. Further research in this field can support the integration of automated voice assistance that will converse with the end-user in simple and comprehensive terms such that an elderly with any level of literacy can use the application.

7.3 Conclusion

In conclusion, this thesis delves into the vital domain of human-computer interaction (HCI) specifically tailored to meet the needs of elderly individuals. This paper's primary focus was to meet the needs of the elderly population and design a user-friendly interface for the elderly. As the population of elderly is increasing so does their technological demand. So there is a need to update the technological landscape to cater to the rising demands of the elderly population. So there is a lot of scope for improvement. That is why we aim to design an eHealth app so that the elderly can gain digital autonomy. By using LLM or a large language model and creating an assistant that can further help in their life.

The key aspect of our research is to find the perspective of the elderly in terms of smartphone interface. To understand the barriers that the elderly face and to get a better understanding of the elderly mind to create an interface. Using the UCD method to analyze and design suitable for the elderly. Also By merging the LLM-based chatbot and Open AI with e-health applications, the thesis aimed to test efficiency, identify optimal integration approaches, and assess limitations to further enhance the User-Centered Design approach for the less technologically inclined elderly population.

Throughout the paper, we had many findings. We found that many eHealth apps did not consider the elderly in terms of interface design. Also, many features were not used by the elderly due to the complexity of navigation and trust issues. Also increasing realignment on caregivers to satisfy their technological needs. Another finding we noticed was that the literate elderly were much more efficient in terms of smartphone usage.

In summary, the effective design of HCI systems tailored to the needs of elderly individuals is crucial in promoting their digital inclusion, independence, and overall well-being. By prioritizing privacy, ease of use, and integrating e-health services, we aim to empower the elderly to leverage technology for their benefit, fostering their independence and access to healthcare resources.

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Chapter 8

Appendix

8.0.1 Demographic Data Of Elderly

These are the data we gathered during our interview to have an in-depth understanding of the demography of our participants

1. What is your age?
2. What is your educational qualification?
3. Do you have experience using Smartphones?
4. How Often do you use Smart Phones?
5. If no why don't you use Smart Phones?
6. If yes, What types of activities do you perform on your smartphone?

Question 1: This is quantitative data which helps us understand our data's distribution over the age group of elderly. In this section, we have the constraint where no data is less than age 65 and more than 80.

Question 2: This is qualitative data which helps us identify the highest educational qualification of our elderly participants. Where in it is an MCQ question. The elderly were asked about their years of engagement in education. If they had completed 10 years of Schooling or more we considered them Educated, Less than 10 years of Schooling to more than 5 were considered Semi Educated, and Less than that were considered Remote to Education.

Question 3. This is a Binary Question which falls under the category of qualitative data. Two options were presented whether they use it or don't. This question helps us determine the technology literacy amongst our participants. Where we do agree that the usage of smartphones does not conclude that a person is technologically literate however it demonstrates that the person has sound involvement with technology and it will help us design our app based on our user's desire.

Question 4: This is qualitative data which helps us to understand the frequency of usage of smartphones by the elderly. This is an MCQ question where we gave the elderly 4 choices.

a. Less than 1 Hour
b. Less than 3 Hours
c. Less than 6 Hours
d. 6+ Hours

This data helps us to apply addiction preventive measures. Like auto turn off apps and shut down the screen. If the participants utilize smartphones more than 6 hours a day the research app will have the addiction preventative measures applied.

Question 5: This is qualitative data. This questionnaire is of Multiple Choice Question question type. We presented the participants with this question during the sessions if they opted to negatively choose question number 3. They were presented with choices such as

a. Smart Phones are too expensive.
b. Smart Phones are too complex.
c. Smart Phones are hard to carry.
d. I don't understand smartphones.

With this, we are doing conclusive categorization. Let's say a participant chooses a and c it means that this is a piece of conclusive evidence that the participant is concerned not about the usage procedure however he is more concerned about the financial viability of the smartphone. Which rules out the response from our research scope and makes it exclusive. If the participant chooses b or d it means that this is conclusive evidence that the participant is concerned about the usage procedure however he is not concerned about the financial viability which includes the response in our research scope. If the participant chooses all the options it supports both cases where he is concerned about the financial viability and usage procedure. This also makes the response inclusive in our research scope. All other cases fall in the exclusive scope.

Question 6. This is a qualitative data. This question is of Multiple Choice Question type. We presented the participants with this question during the sessions if they opted to positively choose question number 3. They were presented with the following options

a. Communication
b. Social Media
c. Entertainment
d. Mailing
e. Reading, Writing books or documents
f. Using health-related app
g. Other Activities

These data would help us to understand the familiarity of our user base with the UI layout. As UI layout plays a vital role in UCD the identification of a layout

depends on the data we included this also gives us crucial demographic information to understand what sort of activity our users perform. Based on this we will be able to make informed decisions in the upcoming process.

8.0.2 Demographic Data Of The Caregiver

Caregivers are the secondary participants in our study. We have identified them as a mandatory extension hand for the elderly and the technical gurus from the perspective of their elderly. Hence their perspective was crucial for us. Thus we first collected their demographic information.

1. How Old are you?
2. What is your educational qualification?
3. How often do you help the elderly with their smartphone usage?

These questions will help us understand the demography. The 1st question is a quantitative question that only takes in values of age, The educational qualification is qualitative, it is divided into the same segments as the elderly and the 3rd question is qualitative data which is an MCQ we provided them with the following options here

a. Everyday
b. Very Frequently
c. Few times a month
d. None

This is a multiple-choice question however this provides us key insight into the dependence of the elderly on technology needs. Hence it will give us further understanding that does their view about a certain type of technology changes the perspective of the elderly on using the technology.

8.0.3 Understanding Elderly's HCI Overview

In this stage, we presented our participants with various apps related to healthcare to find out their opinions about those. Since we are working in this sector if the participants are not interacting with these apps we have to find out why and if they are we have to know the reasoning behind their decision. Thus, we scanned through the Play Store to find different apps that are connected to healthcare and provide their services in Bangladesh. Those apps comprise various features, extending from online appointment booking to video consultations and many more. We presented these question sets to the elderly participants of our research.

1. Do icons and Numbers help you while navigating the design?
2. What Color Choices are visually appealing to you?
3. How do you book doctor's appointments?
4. Would you instead use a computer-based solution for doctor's appointments?
5. Did you ever use a video consultation facility with a doctor through consultation apps?

6. Will you be using a video consultation facility provided by an app? State your reason
7. How do you communicate with your doctors?
8. if you have a native doctor with whom you communicate using phones what type of conversation mostly goes on?
9. if you do not have a native doctor do you think you will use an application that will suggest you the right doctor for your diseases?

Description of the Questions: 1 is a qualitative question here this question was asked to confirm if icons and numbers are necessary for the navigation button. This was a binary question.
2 is a qualitative question here in this question we asked about the colour choices of the users whether they liked darker colours or vibrant colours. This question was taken into consideration while designing our app
3 is a qualitative question here we provided multiple choices like,

a. website
b. direct calling
c. walk into the hospital
d. eHealth apps.

From our analysis of the apps the apps did contain online appointment booking and so did the websites. So we considered practically if it is really necessary to include appointment booking in our application.

In 4th question, we want to confirm our understanding with the participant's confirmation. This was a binary question.
The apps that we surfaced also had video consultation facilities so in an app for the elderly we want to be sure if the elderly want this facility or not hence the 5th question which is a qualitative binary question was asked the 6th also is related to it this question has two parts both the parts are comments so this has no other options. With this, the last question for evaluation 7th contains multiple choices such as Directly via Phone, Messenger, Person to Person. This is because some people might have native connections with their doctors and thus we want to know if they are unknowingly using the e-health services. When we use an app such as messenger or phone calls to directly contact our doctors that falls under the category of e-health there might be a lack of understanding of the definition thus they might not answer the previous question correctly. The 8th question better explains what type of services are crucial for us to implement. This is an MCQ-based question. And Qualitative data we get from it. This is important because it narrows down our field we have chosen the options carefully from our understanding.

a. You have a disease and want medicine from him.
b. If no medicine then what to do.
c. You send him pictures and reports.
d. Others

The options were carefully catered. If a person has a native doctor they will try to get medicine from the doctor if not then what shall they do the doctor might suggest he send a report and infected area pictures if that is appropriate and visible

or in other cases the section becomes too niche to gain specific data about it.
The 9th question was catered by carefully considering the scenario that what if a native doctor is not accessible by an elderly person in that case what will the elderly person do? Will they use such a service? This question is qualitative, we gave them the options such as

a.Yes
b.No
c.Maybe if the app is from a trusted medical provider

8.0.4 Understanding Caregiver's HCI Overview

After the HCI perspective of the elderly as caregivers are vital in the elderly's daily life their perspective had to be understood. To do it we asked them the following questions

1. How do you book doctor's appointments for the elderly
2. Will you be willing to use e-healthcare platforms for this?
3. How do you decide which health care professional to go to?
4. Has there been an instance that you went to a doctor and they suggested you another doctor?
5. Was it an inconvenient experience for you and the elderly?
6. If there is an app that can suggest to you the right doctor based on the symptoms will you use it?

These question sets will help us understand the HCI overview of the caregiver and also an idea of what is needed.
For the 1st question we have decided on qualitative data responses, we provided them with the options such as

a.Calling doctor's office
b.Going there physically
c.Using Website
d.Through E-health applications
e.Others

For the 2nd question, we used qualitative responses. We gave them the options of Yes, No, Maybe
For the 3rd question, we used qualitative responses. We gave them the options such as

a.By reaching out to a familiar physician.
b.By conducting a Google search for the symptoms.
c.Using general knowledge as a reference about the symptom
d.Other

For the 4 th question we used binary responses which is qualitative data.
For the 5th we used qualitative data such as yes, no, somewhat
For the 6th we are using a combination of binary responses and additionally, we are asking them that maybe, if the app is from a trusted medical source and provides correct information.

8.0.5 Appointment Booking Professional's Questions

Also to verify anything related to appointment booking we asked the appointment booking professional the following questions,

1) How do you manage an appointment?
a. Phone Calls
b. Application
c. Email

this is qualitative data which will give us further idea about whether it's viable to make an appointment booking feature in the application. As in UCD, we must verify our idea with all stakeholders.

8.0.6 Likert Scale Questions

1. Do you find our app satisfactory?
2. Do you think the Smart Desk feature is useful?
3. Do you think the Primary Care Chatbot feature is useful?
4. What is the likelihood of you using the app?

8.0.7 SUS(The System Usability Scale) Question

1. I think that I would like to use this system frequently
2. I found the system unnecessarily complex
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system
5. I found the various functions in this system were well-integrated
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.