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Master Thesis

# Analysing e-Health in Iran: A Requirement Engineering Perspective

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*"Medicine considers the human body as to be the means by which it is cured and by which it is driven away from health"*

*Ibn Sina*

*Ibn Sina, also known as Avicenna in the Western world, was an eminent Iranian philosopher, physician, and scientist. His substantial contributions to medical science have earned him the global title 'father of early modern medicine'.*

**Acknowledgment:**

I want to express my profound gratitude to those who have made the completion of this thesis possible. I am deeply indebted to many individuals who have contributed directly and indirectly to the work embodied in this study.

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# Abstract

***Context***. The advancement of e-Health in Iran is hampered by conditions unique to the context of this country. In the context of this research, we aim to provide methods to analyse e-Health system and design ways of improvement.

***Goal***. We aim to propose a method that serves as a knowledge approach to analyze the complex context of the e-Health system in Iran. Our goal then shifts to a design approach aimed at understanding stakeholders' requirements and designing applications for specific use cases of e-Health system in Iran.

***Method***. We applied requirements engineering-based method for analysing the complex context of e-Health in Iran and designing solutions for specific use cases based on stakeholders' requirements. This method involves stakeholder analysis, IT infrastructure evaluation, conceptualizing the interviews' findings with a BPMN method, and prototyping in an iterative process. This method can be applied in other developing nations to analyse context and design solutions.

***Results***. As a result, we understand the complex context of Iran's e-Health, designed and developed two user-centric applications, namely DargahRahyab and DaroRahyab for our exemplary use cases in Iran's complex e-Health system. DargahRahyab integrates insurance portals and add an additional layer of biometric authentication, while DaroRahyab assists patients in finding rare medicines. The developed applications were well received by stakeholders.

***Conclusions***. In conclusion, we conducted a broad context analysis of the Iran's e-Health system, gaining insights into the unique challenges. Following this, we transitioned to the technical approach and developed user-centric applications for specific use cases. This process can be presented as an adapted ICT4D method to understand complex contexts of e-Health in Iran. The contributions of this study are two requirements-engineering based approaches: (i) Presenting a knowledge approach for analyzing the context of Iran's e-Health system. (ii) Presenting a design approach for designing and prototyping e-Health solutions technically for the specific use cases in Iran's e-Health system.

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# 1

# Introduction

This master's thesis undertakes an informative journey into the heart of Iran's healthcare ecosystem, illustrating the unique circumstances and unfulfilled potential of e-Health systems in this country.

The e-Health implementation in Iran is in its early steps and is expected to further expand the coming years. The journey of e-Health in Iran is significantly different from that in other countries, owing to the country's unique circumstances: the international technological and economic sanctions and internal political issues have completely isolated this developing country in the Middle East from knowledge sharing and international trade. Due to these conditions, many medical doctors have left the country, causing an enormous brain drain in healthcare delivery services. Most of the e-Health development in Iran is based on domestic technology. International companies are not allowed to provide services and facilitate e-Health development.

In this thesis, we conduct a requirement engineering method to analyse and comprehend the context of e-Health in Iran and design technical e-Health solutions for this complex context. Requirements engineering is the process of eliciting stakeholder needs and desires and developing them into an agreed-upon set of detailed requirements that can serve as a basis for all subsequent development activities (1). To do so, we used an adopted ICT4D methodology to understand gaps and limitations in e-Health delivery from health workers into patients in complex context of Iran's healthcare system and designed solutions for particular use cases based on stakeholders' requirements. Our research methodology includes four main phases: (i) interviewing local stakeholders (doctors, health workers, and patients), (ii) conceptualizing the findings from the interviews using a Business Process Modeling and Notation (BPMN) method, (iii) collecting user requirements and (iv) prototyping new e-Health solutions for two exemplar use cases: (1) An integrated electronic

prescription system namely DargahRahyab in the Persian language, that facilitates and improves the current e-prescription (2) A user-centric application which facilitates finding rare medicines for patients namely DaroRahyab.

By combining these four methods pragmatically while applying a collaborative, adaptive, iterative approach to context analysis, needs assessment, and requirements analysis, we can obtain and present a clearer picture of the gaps and limitations of the e-Health delivery domain in Iran.

The main findings of this research are that we analyzed the complex context of Iran's e-Health and designed and developed user-centric applications for specific use cases throughout (i) A requirements-engineering-based Knowledge approach to analyze and comprehend the context of e-Health in Iran. (ii) A requirements-engineering-based design approach for finding the requirements of key stakeholders and designing appropriate e-Health solutions for addressing specific stakeholders' requirements.

This thesis is structured as follows: *Chapter 1* details the adopted ICT4D requirements-engineering-based methodology employed in this master's thesis. *Chapter 2* provides a comprehensive context analysis, including a stakeholder analysis conducted through semi-structured interviews. *Chapter 3* involves the finding requirements of stakeholders and the identification of correlations between these requirements and the unique challenges in Iran. In *Chapter 4*, we evaluate the IT infrastructure in Iran, considering its potential impact on our final e-Health artifacts. *Chapter 5* conceptualizes the interview findings using the Business Process Modeling and Notation (BPMN) method, discussing our models in detail. *Chapter 6* transition into the design of e-Health use cases for the complex context of e-Health in Iran, approached in a user-centric way. Here, we evaluated and prioritized use cases, preceding the prototyping phase. *Chapter 7* explains the development phase of the project and the technical aspects of developing the e-Health applications. We also verified our designs and prototypes by requesting stakeholder feedback on our proposed solutions. In *Chapter 8*, we discuss the limitations of our research, and *Chapter 9* concludes the thesis results and provides contact information, project presentation slides, and a GitHub links.

## 1.1 Research Questions

**Research Question 1 (RQ1):** *How can we analyze a complex context such as healthcare in Iran to understand the state, challenges, and limitations of e-Health in the country?*

To answer Research Question 1, we employed an adopted ICT4D requirements-engineering based method to analyze and understand the complex context of e-Health in Iran, including stakeholders' analysis, identifying unique challenges, prioritizing stakeholders based on their level of power and interest, utilising the Business Process Model and Notation tool for modeling, and understanding the IT infrastructure limitations. The result of applying this knowledge approach can be found in the second, fourth, and fifth chapters of this master's thesis.

**Research Question 2 (RQ2):** *How can we identify the needs and requirements of stakeholders in the health sector to design appropriate user-centered e-Health solutions within a complex context, such as Iranian healthcare system?*

To answer Research Question 2, we carried out stakeholders' needs assessments, designed and prototyped solutions, and prioritized use cases based on designed criteria such as cost and feasibility. Additionally, we verified the output by presenting the developed solutions to the key stakeholders. The results of applying this design approach are detailed in the third, sixth, and seventh chapters of this master's thesis.

## 1.2 Methodology

In this study, a systematic, iterative approach based on requirements engineering principles was utilized to comprehensively understand the current status of Iran's e-Health system and design and propose possible solutions for stakeholders' needs and requirements, before developing applications for specific use cases.

The first phase of our iterative research methodology required a comprehensive understanding of the context, which included exploring Iran's existing healthcare environment and its unique challenges and analyse of stakeholders. In this phase of research that started in November 2022, we conducted comprehensive semi-structural interviews. Unlike quantitative studies, which typically conclude data collection before initiating data analysis, our qualitative data collection and context analysis occurred iteratively. As more data was collected, we moved between data collection and data analysis processes, allowing for the emergence of new lines of inquiry (2). This iterative approach in context analysis phase enabled us to revisit and modify multiple stages in response to newly discovered findings or inconsistencies. Understanding unique challenges and the existing healthcare environment in Iran during context analysis was fundamental. This is because of this fact that factors related to specific contextual characteristics could directly impact e-Health research and probable solutions to potential problems (3).

Following the context analysis, we moved to the needs assessment phase as the second phase of our research methodology. After conducting interviews with healthcare stockholders and hearing their stories, we understood their needs and expectations for the e-Health system in Iran. In this phase of the methodology, we were supposed to assess the stockholders' needs, goals and potential obstacles.

The third phase of our research was an exhaustive IT infrastructure evaluation, during which we identified any deficiencies, gaps, or constraints that might hinder the performance of the proposed system. We were particularly attentive to the specific challenges that might have impacted IT infrastructure in Iran.

In the next step of the study, we conceptualized the findings from the interviews using a Business Process Modeling and Notation (BPMN) method. This tool gave us the opportunity to understand the current state of the e-Health system in Iran comprehendingly. We also verified the models by presenting the simplified version of them by animation to the stakeholders and adjusted it when we found incoherences.

In the following phase, we set priorities for feasible and necessary designed solutions using the findings from the phase needs assessment and IT infrastructure assessment phases.

Thus, we were able to produce a comprehensive list of project ideas or a portfolio of crucial concepts for the e-Health ecosystem in Iran. This phase can be seen as the second step of need assessments, where we explored the solution space and set priorities based on costs, time, feasibility, and technical skills. In this phase of research we select the key ideas for potential use cases, which are most interesting for the users, balanced against technical and cost considerations(4).

Subsequently, the system entered the development phase, where the technical blueprint was transformed into a functioning entity. In software parlance, a blueprint is the high-level plan or outline depending on which the end product, that is the software, is going to build. The phase was fundamentally user-centric, based on the belief that the system's usability and acceptance significantly depended on how well it met its users' requirements. We used iterative feedback from potential users to guide the design process, fostering a system that was not only efficient but also intuitive and engaging. At the end of this phase of study, we present stakeholders about the output of our work for verification of our research results. The adopted methodology is shown in figure 1.1.

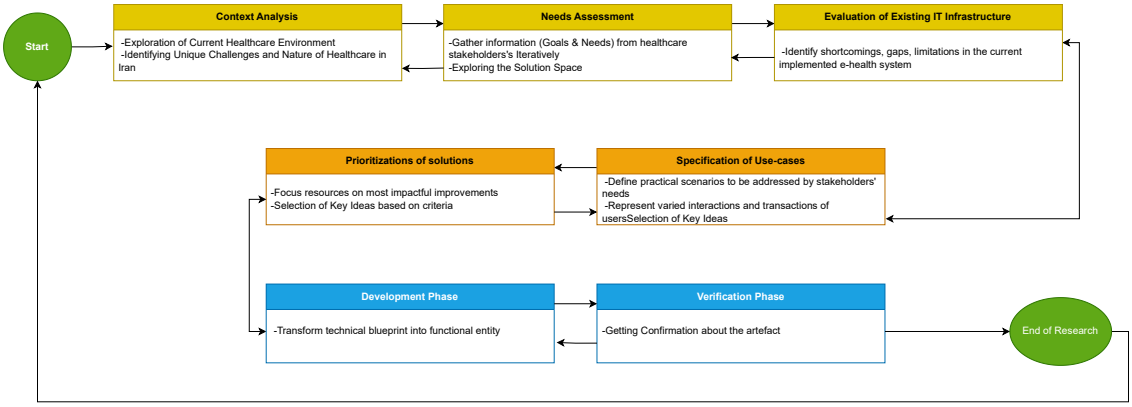



**Figure 1.1:** Research Methodology Diagram

### 1.2.1 Context Analysis

The scale of context analysis phase in this research started from individual perspectives to broader social, operational, and regulatory factors influencing e-Health implementation. This current context analysis is a multi-level analysis, integrating micro (individual) and macro (societal, operational, policy) levels. It is critical to analyse the context of a society, since contextual factors affect implementation of information systems in general and

e-Health projects. According to this study (3) context factors, like culture, affect the implementation of any ICT project, including e-Health related projects. In order to gather information and analyze e-Health developments, we used most common approach that can be used in qualitative healthcare research (5), namely comprehensive interviews [1] with key stakeholders, to analyze the current state of e-Health implementation in Iran. The interviews were conducted in a semi-structured format, allowing for flexibility and enabling a profound understanding of e-Health, as a complex ecosystem. Unlike structured interviews or questionnaires, semi-structured interviews allow us to adjust questions based on responses and the flow of the conversation, ensuring a comprehensive exploration of complex topics. This interview technique was chosen as it allowed us to clarify and probe responses, ensuring accurate interpretation and capturing the nuances of participants' perspectives.

### 1.2.2 Needs Assessment

In the needs assessment phase, we used conducted semi-structured interviews for the purpose identifying stakeholders' requirements, as an essential step in the collaborative approach to ICT4D projects (4). This phase of need assessment was two-fold. The first iteration acquainted us with the operational objectives of the intended users and helped us identify the prevailing limitations that might hinder progress. This was considered an introductory exploration of the problem space (4). The outcome was a list of requirements and preferences expressed by the main e-Health stockholders. We proceeded to the second step of the needs assessment, where we explored potential solutions and set priorities. However, this part of the process was conducted in the fourth and fifth phases of our project based on adopted shown methodology in figure 1.1. This is because we first needed to assess the existing IT infrastructure in the third phase before suggesting any design and prototype. This second step of need assessments generated a comprehensive list of potential project for specific use cases. Also, we are aware that needs assessment techniques might sometimes fall short for ICT4D projects due to unique challenges such as socio-economic factors, cultural differences, digital literacy, and lack of sufficient IT infrastructure(6). With the employing semi-structured interview technique, we were able to grasp the target population's needs, objectives, and tasks, aligning them with higher-level social development goals. Our data included diverse sources like healthcare providers, administrators, and patients, helping us to determine the fundamental requirements for an efficient e-Health system in Iran.

[1] Detailed information regarding these interviews, including transcripts and summaries, can be found in the appendices.

### 1.2.3 Evaluation of Existing IT Infrastructure

In order to increase the efficacy of existing systems, enable the creation of innovative tools, and introduce solutions for potential problems in Iran's e-Health ecosystem, it is imperative to conduct an accurate assessment and understanding of the required infrastructure. In this methodology phase, we perform a detailed review of the prevailing infrastructure, focusing on IT infrastructure, including both software and hardware, and the digital techniques used to record medical data in prior years. During this evaluation, it was determined that significant infrastructure inadequacies exist in Iran. The enforcement of technological and economic sanctions by the United States can be one of the probable reasons for significant infrastructure inadequacies. According to various uncommon circumstances like international technology sanctions and serious political issues in this country, most IT-related implementations must depend on domestic products, making development costly and time-consuming.

### 1.2.4 Business Process Model and Notation (BPMN)

With the help of identified patterns from conducted interviews, we developed a conceptual model of the current status of e-Health in Iran using the BPMN (Business Process Model and Notation), a standard IT-based tool for the graphical representation of business processes. Although health care system complexity and the challenge of consumer health literacy hinder greater engagement, BPMN workflow language can be a good approach to formalize the description of navigation processes derived from medical guidelines and develop a healthcare systems to evaluate various clinical activities from multiple perspectives (7). The BPMN models visually describe the processes and workflows involved in e-Health implementation and the factors influencing its adoption. As a novel method for verification of BPMNs, we created animations based on the BPMN models. These animations present a simplified version of the e-Health procedures and BPMNs to end-users (patients and healthcare providers), ensuring the BPMNs validity and reliability in an interactive process. The animations include Persian subtitles and feature a computer-generated voice-over explaining each process step. The creation of the animations took place concurrently with the development of the BPMNs. Although creating these animations were time-consuming, they provided a clear and engaging depiction of how e-Health processes work, allowing end-users (patients and healthcare providers) to verify that the model accurately reflects their experiences with e-Health systems in Iran. The table 1.1 shows the number participants involved in BPMN diagrams verification with animations.

| BPMN Model Name | Involved Doctors | Involved Patients |
|---|---|---|
| Making Appointment with Phone Call | 1 GP, 1 Specialist | 5 |
| Online order Over-Counter Medicines | - | 6 |
| Online order Prescribed Medicines | - | 6 |
| E-prescription Process | Insurance's portal user manual was used. | |
| Prescribing Tests in Public Medical Lab | 1 GP, 2 Specialists | 3 |
| Prescribing Tests in Private Medical Lab | 1 GP, 2 Specialists | 3 |
| Receiving Digital Prescription Process | 1 GP, 2 Pharmacists | 2 |
| Visiting Health Home Centers | 1 GP | - |

**Table 1.1:** Detail of End Users Involved in BPMN Diagrams Verification with Animations

### 1.2.5 Specification and Prioritization of Use cases

After conducting an exhaustive examination of the local milieu coupled with a systematic appraisal of the existing e-Health framework, we embarked on an in-depth needs assessment. This rigorous exploration gave us profound insights into these users' fundamental requisites and challenges. This approach guarantees that the devised solutions fulfill the users' requirements and coalesce seamlessly with the established infrastructure. This enhances the overall efficacy and usability of the e-Health system within the Iranian context. In this research stage, we also prioritized the solution scenarios, considering the unique needs of key stakeholders. This strategic prioritization allows us to concentrate resources on areas that promise the most significant improvements, thereby maximizing the impact of our efforts. Some of these expectations appeared to be unrealistic or costly. For example, one specialist proposed that Iran's Ministry of Health provide a smart card for each patient, with all medical health records saved for confidentiality and users' comfort. The patient would then bring this smart card to each doctor visit. However, this solution is not feasible due to its high cost, time-intensive nature, and the technical challenge of storing extensive information on a single smart card.

Moreover, some of the needs and features that healthcare stockholders expected already exist within the current e-Health system. They, however, were unaware of these features. For instance, it is possible to print a prescription with a digital signature via the current e-Health portal for patients who need paper-based prescriptions, whereas two doctors believed they could not provide paper-based prescriptions.

However, some stockholders' needs were logical, and practical solutions could satisfy their expectations.

### 1.2.6 Development and Artefact Verification

In the final phase of the research, we discussed the development and technical aspects of the project. Initially, we will explain why we chose to use Flutter, as an open-source framework created by Google for building smooth and scalable cross-platform applications, and then discuss how we endeavored to make our artifact secure for users. We have included some screenshots of our developed artifacts. At the end of this phase of research, we verified our applications by asking from key stakeholders.

# 2

# Context Analysis

In this study chapter, we analyse Iran's current e-Health landscape, including current state, unique challenges, limitations of e-Health system and critical stakeholders who engage with this system as part of process of addressing the Research Question 1 which is *"How can we analyze a complex context such as healthcare in Iran to understand the state, challenges, and limitations of e-Health in the country?"*. Figure 7.1, determine the current phase of the research.

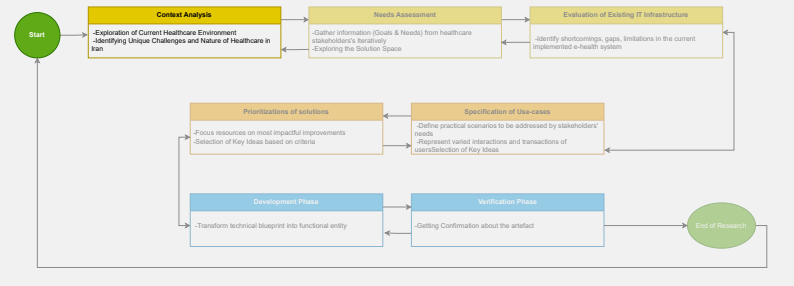



**Figure 2.1:** Context Analysis (First step of methodology)

## 2.1 A Brief Overview of Iran's Healthcare Ecosystem

Iran is a nation in West Asia and the Middle East. Iran is partitioned into 31 provinces based on geographical and administrative demarcations. This nation has a landmass of 1,648,196 square kilometres, making it the second most extensive country in the Middle Eastern region and the 18th largest globally according to wikipedia[1]. The population of Iran is more than 86 million people according to Iran Statistics Department [2] in 2022, and

[1]Link to wikipedia
[2]https://www.amar.org.ir/statistical-information

Tehran is the capital and the most populated city of this country. The life expectancy in Iran is 76.5 years (75 for men and 78 for women), ranking 73rd in the world. Iran's healthcare sector is a mix of public and private services. According to 2016 statistics [1], nearly 75% of the hospital beds in Iran were from the public sector. The per capita number of hospital beds in 2018 was 15.6 hospital beds for every 10,000 people according to WHO statistic information [2], though their distribution across provinces is uneven. The visual comparison of per capita number of hospital beds in this country in 2018 for every 10,000 people can be seen in figure 2.2. In the context of digital literacy and infrastructure, Iran has seen significant growth, with increasing Internet penetration and smartphone usage, laying the groundwork for developing and implementing e-Health initiatives. Addressing potential healthcare challenges through e-Health could improve healthcare delivery, access, and outcomes across Iran's diverse provinces.

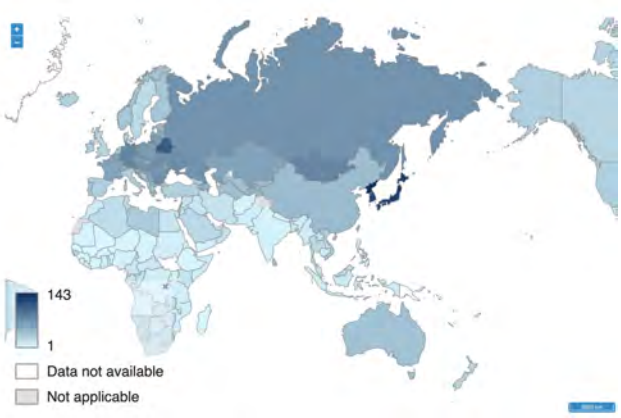



**Figure 2.2:** The per Capita Number of Hospital Beds in this Country in the year 2018
Source Link

## 2.2 Identifying Unique Challenges and Nature of Healthcare in Iran

The advent of e-Health has significantly altered healthcare systems worldwide. Similarly, Iran has been experiencing this transformation, transitioning quickly towards an electronic-based healthcare system - a shift particularly intensified during the COVID-19 pandemic. However, Iran's e-Health development differs from patterns seen in other regions, predominantly developed countries. This variation can be primarily attributed to the unique

[1] https://www.amar.org.ir/statistical-information
[2] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/hospital-beds-(per-10-000-population)

socio-political and cultural factors that underpin the country's innovation and advancement in the e-Health sector that we discussed in detail in below subsection.

### 2.2.1 The Influence of Cultural Norms and Legal Framework on Healthcare Data Privacy

One unique factor is the cultural norms prevalent in Iran, which deviate from those of many other nations. Interviews with healthcare providers and users have revealed that, unlike their counterparts in developed countries, Iranian patients and healthcare providers are less concerned about healthcare data privacy and protection. This perspective is partly due to the absence of a comprehensive, centralized legislative framework for data protection similar to the General Data Protection Regulation (GDPR) in the European Union or CCPA ( California Consumer Privacy Act) in the united states of America. Although Iran's 'Law of Patients' Rights' in the constitution addresses patient privacy in the healthcare ecosystem, it does not explicitly cover the e-Health aspects mainly. It is less exhaustive and detailed than laws in many other countries. This law, comprising twelve provisions, outlines a policy framework for patient confidentiality, privacy, and respect within medical organizations, underlining key points including:

- The obligation to uphold confidentiality for all patient information.
- The mandate that breaches in confidentiality can only occur under legally defined circumstances, with the patient's knowledge.
- The requirement to provide patient information to judicial authorities only in response to official court inquiries.
- Medical personnel expects to respect patients' privacy, avoiding intrusive activities.
- The provision for patient companionship during diagnosis and treatment stages, barring any disruption to standard medical procedures.
- The stipulation is that any interaction with media should not violate the patient's privacy or compromise public trust in the profession.
- The rule is that managers should respect patients' privacy when discussing patients, particularly public figures.
- The condition is that patient photos and data can only be used for educational, research, or treatment purposes with the patient's consent or the approval of an ethics committee.

### 2.2.2 Cyber Threats and Data Security in Iran's e-Health System

Due to a variety of foreign political issues and a perceived lack of amicable collaboration with other nations, Iran is constantly under high risk of various cyber attacks. These cyber threats have compelled policymakers to restrict access to almost all governmental websites and crucial portals, including insurance portals, from outside Iran. This measure can be seen as a preventative action aimed at protecting internal data centers, which predominantly utilize domestic technology, from external hackers. According to a study titled "Security Evaluation of Hospital Information Systems" (8), an extensive assessment was conducted to gauge the security levels of Hospital Information Systems (HIS). The researchers used a checklist of 134 questions, developed by first identifying security criteria from established standards and then determining HIS security requirements across three domains: administrative, physical, and technical safeguards. The responses to the checklist questions were categorized as Yes "1" or No "0", and the security level of HIS was gauged on a five-level scale, ranging from very low (0%) to very high (100%). Data were analyzed using descriptive statistics, including frequency and percentage. The study revealed that administrative safeguards of HIS in the examined hospitals had a low level of security, standing at 31.8%. Physical safeguards were also found to be at a low level, at 25%. On the other hand, technical safeguards of HIS in hospitals were found to be at a medium level of security, with 42.6%. Also according to this study (9) the challenges of e-Health utilization in Iran mostly relates to standardization of e-Health applications and also improper privacy and security mechanisms. A significant recent instance of a cyber attack on the Basic Iranian Insurance system involved unauthorized access to the MRI image of an injured girl by Iran's moral police based on this news by Iran International [1]. The government hesitated to reveal the specifics of what happened to this girl. According to Iran International News and one of our interviews, a cyber group easily breached the Iranian medical records system, retrieved the MRI image, and then published it in the interest of transparency. Another example, Voice of America (VOA) published a news that "In the continuation of the attack on Iran's government websites, the website of the Forensic Medicine Organization was also hacked" in September 2022 [2]. This incident underscores the growing threats to healthcare systems and the urgent need for strengthened security measures.

[1] Iran International is a Persian language news television channel headquartered in Washington, D.C. aimed at Iranian viewers, and broadcasting free-to-air by satellite. News Link: https://www.iranintl.com/202209199159

[2] Voice of America is the state-owned news network and international radio broadcaster of the United States of America. It is the largest and oldest of the U.S.-funded international broadcasters. News Link: https://ir.voanews.com/a/hacker-iran-spider-youranonspider/6757484.html

### 2.2.3 Effects of Political Issues and Internet Governance on e-Health Access

Political issues resulting from incorrect determinations by policymakers might affect residents' access to the Internet. Governance in Iran restricts Iranian residents' access to free Internet during occasional protests against the government's erroneous political decisions. For instance, over the last year, the Internet has been restricted or entirely disconnected by policymakers several times. According to the Open Observatory of Network Interference (OONI), "Over the years, Iranian authorities have followed a pattern of blocking social media apps and numerous websites, and even resorting to shutting down networks entirely, implementing overall pervasive levels of Internet control. The latest shutdown events in Iran in September 2022 amid ongoing protests follow the same pattern." Figure 2.3 shows an example of a widespread Internet shutdown in this country in the year 2022. According to one of our interviews, a pharmacist mentioned that pharmacies have experienced various difficulties every time the government shuts down the Internet, and patients suffer from these decisions. This is primarily because pharmacies depend on the Internet to access e-prescriptions, and their access to the Internet can be seen as one of their primary and essential requirements. If the government shuts down the Internet entirely or reduces the bandwidth, patients, particularly those with urgent and necessary medication, cannot collect their medicines from the pharmacy. They also cannot easily make another appointment with their doctor to change the e-prescription into a handwritten prescription due to long waiting times. It should be noted that these shutdowns occur unexpectedly and sometimes might last around two weeks. This pharmacist believed that this disconnection and inconsistent Internet connection might be a significant reason why using e-Health is not mandatory, and both patients and doctors have options to choose between handwritten and electronic prescriptions. Internet shutdowns can effectively disrupt e-prescriptions, hinder access to patients' medical records in emergencies, and even impede research in universities.

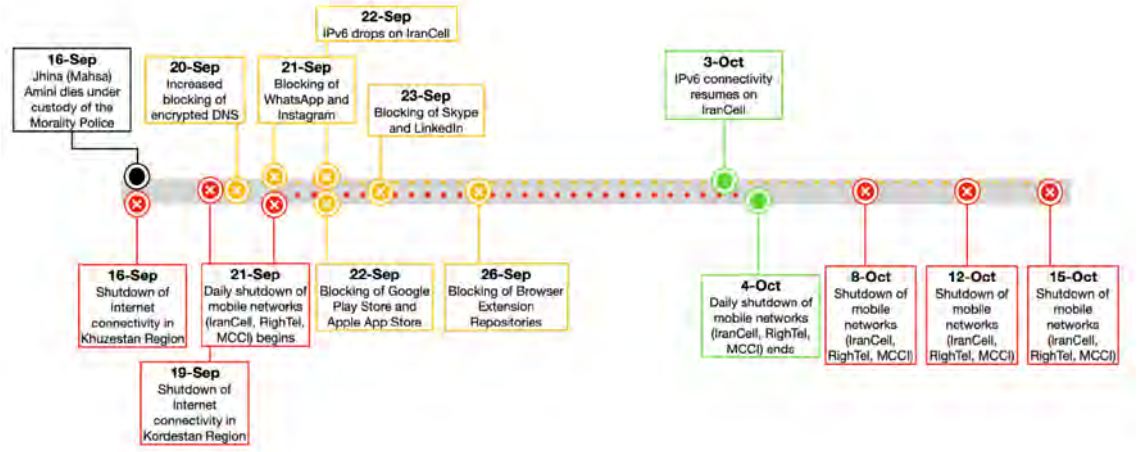



**Figure 2.3:** Timeline of Internet shutdown in Iran between 16th September 2022 to 16th October 2022 Source Link

### 2.2.4 International Sanctions, Economic Challenges, and their Impact on e-Health Development

International sanctions considerably influence the progression of e-Health in Iran. Due to restrictions the United States imposes on Iran, international firms are prohibited from economic or technological collaborations with the country. Sanctions' impact on Iran's healthcare system was divided into five categories(10): (a) financial issues, (b) difficulty supplying laboratory materials and (c) equipment, (d) disruption in international research collaboration and activities, and (e) increased working stress. According to this study (10), sanctions have had a significant impact on Iran's health research system because research centers in Iran are heavily reliant on government funding. Financial and economic issues, restrictions on transferring funds, and disruptions in political and international relations have all made it difficult to supply medical laboratory materials and equipment to Iranian medical and health research centers. As a result of technological sanctions in this country, Iran has been fully isolated in terms of using developed technologies by other nations and has to rely solely on domestic technologies, such as software and hardware. For insurance, Oracle, an American multinational computer technology company, banned Iran's resistance to using any software related to this company. This is on the condition that Oracle's big data services can be benefited data professionals' management, cataloging, and processing of medical data. Another example that shows Iran is dependent

on domestic IT development can be the matter that none of the international Internet providers, such as Vodafone or t-mobile, can offer services to Iranians inside Iran, and this country has its local Internet service providers, including HAMRAH AVAL (MCI), MTN Irancell, and RighTel. As another restriction resulting from International sanctions, we can see that Iran has been facing restrictions that hinder communication with most global scientific communities and obstruct the exchange of medical and scientific information with foreign universities. Also, some Iranian citizens require a specific education permit from the United States to study sensitive subjects in higher education institutions worldwide. This limitation curtails access to updated information essential for any IT-related development, including e-Health. The International boycotts also have contributed to economic challenges for the people living in this country, which can be seen as a significant side effect of International sanctions. As a result of economic challenges, internal and external healthcare providers' migration is happening in Iran. Healthcare providers living in remote and sparsely populated provinces try to migrate to big cities like Tehran, the capital of Iran, to make more money. This internal migration has contributed to severe shortages in the medical workforce in Iran's remote, border, and deprived regions and provinces. At the same time, some other healthcare providers try to find a job in more developed countries to have comfortable living with higher incomes. According to British Broadcasting Corporation Persian(BBC Persian) [1] report in December 2022 (11), officials in Iran's medical and therapeutic institutions have warned about a potential shortage of specialist doctors in the coming years. According to the head of Iran's medical system organization, "the fact that the wave of immigration has gone to specialist and subspecialist doctors is a serious alarm." Mohammad Raiszadeh, head of the medical system organization, told ISNA [2] that "the issue of immigration has been around for a long time, but now it has increased its momentum." This year, "about five thousand" doctors have requested a certificate of "no medical history" from the Parashki system for immigration. It does not mean that all these people left the country. They just applied. More than a third of these people are general practitioners. He warned that "not in the distant future" but in the "next five years," Iran's medical system will face "irreparable crises" and "if it continues like this, we will be forced to go back," and patients should be sent to "Let us send abroad and bring foreign doctors to the country." Iraj Fazel, head of the Iranian Surgeons' Society, told Ham Mihan

[1] BBC Persian is the Persian language broadcast station and a subsidiary of BBC World Service which conveys the latest political, social, economic, and sports news relevant to Iran, Afghanistan, Tajikistan, and the world.

[2] A news agency run by Iranian university students

newspaper [1]: "The wave of migration cannot be ignored. Every doctor and surgeon who goes is a big hurt. Today, it has reached a point where everyone who can go, and mostly only those who cannot go, stay."

### 2.2.5 Sever Medicine Shortage

Iranian patients have experienced increased pain and suffering as a result of a lack of timely access to medicines in general, and lifesaving medicines such as chemotherapy medicines in particular, due to the sanctions imposed on Iran(12). According to the Hamshahri Newspapers [2], "evidence shows that medicines are not readily available and applicants have to visit several pharmacies to find the medicine they need. [3]". As part of e-Health development by the Ministry of Health, a global database exists that connects all the country's pharmacies. Pharmacies are supposed to keep this database updated, and refer patients to the pharmacy where they can collect the medicine if it is not available at their location. However, according to our interview with Dr. Mohammad Ali Abotorabi, only a minor proportion of pharmacists keep this database updated, making this e-Health solution seem ineffective. The lack of motivation to maintain this database might be due to the time-consuming nature of manual updates. The process is manual because the database and its associated software are not integrated into the basic Iranian insurance system, but rather were designed and developed by the Ministry of Health in Iran. Thus, it is a manual task, and the database does not get updated when pharmacists prepare prescriptions through the insurance e-prescription portal. This unique problem results in significant challenges for patients who need medicine immediately. In such situations, patients must check various pharmacies and ask for rare medicines. According to Hamshahri Newspapers, "The shortage of medicines, especially antibiotics, began across the country from around December 2022 and peaked in January 2023. So much so that the country's one-month drug reserves were in a red state, and available medicines like cough syrup, serum, children's acetaminophen syrup, ibuprofen tablets, eye drops, etc. became scarce in some pharmacies. Citizens had to traverse the city's pharmacies to find even the simplest drugs that were always available.[4]".

[1] Ham-Mihan was a reformist daily newspaper in Tehran, Iran.

[2] Hamshahri is a major national Iranian Persian-language newspaper. This newspaper owned by municipality.

[3] Link to news: hamshahrionline.ir/x8frb

[4] Link to news: hamshahrionline.ir/x8frb

### 2.2.6 Migration Trends and its Consequences on Iran's Healthcare System

A significant crisis that pushes Iran's healthcare system is the influx of illegal migration from neighboring nations like Iraq and Afghanistan. These countries' ongoing wars and instability have forced their citizens to seek refuge in Iran. According to the United Nations High Commissioner for Refugees's (UNHCR) [1] latest figures communicated by the Government of Iran, 800,000 refugees live in Iran, of which 780,000 are Afghans, and 20,000 are Iraqis. Additionally, it is estimated that some 2.1 million undocumented Afghans and nearly 600,000 Afghan passport holders live in Iran. Since the upheaval in Afghanistan in August 2021, the number of Afghans in need of international protection has increased. According to various government estimates, 500,000-1,000,000 Afghans have newly move to Iran since the deterioration of the situation in Afghanistan in 2021. This inflow further burdens Iran's healthcare system, which is already struggling to serve its population adequately. The Iranian basic insurance companies, including Social Security insurance, Iranian health insurance, and Iranian armed forces insurance, have facilitated all e-Health advancements in Iran in recent three years. These companies solely provide services to legal residents, with their offerings tied to the Iranian National ID system. Making electronic healthcare services mandatory, such as e-prescriptions and healthcare history, poses significant challenges. These circumstances create a conundrum for illegal immigrants who lack the necessary identification (estimated 2.1 million undocumented Afghans). Without access to these digital services, they are effectively excluded from receiving essential healthcare services. This exacerbates the pressure on the healthcare system, creating gaps in care delivery, increasing the risk of public health crises, and contributing to a more significant socioeconomic problem. Moreover, this situation underscores the need for inclusive strategies that account for the entire population within the country's borders, irrespective of their legal status. Providing healthcare services to all, particularly in the context of public health emergencies, is a moral imperative and crucial to overall public health security. Thus, policy reforms and collaborative efforts among health stakeholders are needed to address these challenges and ensure equitable healthcare access for all individuals residing in Iran.

[1] https://www.unhcr.org/ir/refugees-in-iran/

### 2.2.7 Dependency on Private Sector in Iran's e-Health Development

The private healthcare sector, including insurance companies and private startups, directly drives e-Health-related advancements in Iran. Policymakers, such as the Ministry of Health in Iran, primarily manage and regulate various aspects of the e-Health system. The responsibility of policymakers encompasses establishing regulatory standards, the assurance of quality control, and the facilitation of appropriate and equitable access to electronic health services. Additionally, they work to create a facilitative atmosphere that promotes innovative practices and the assimilation of novel technologies. The task of monitoring the present e-Health system by policymakers may be viewed as a favorable undertaking. However, there exists a necessity for policymakers to possess greater authority to forestall the private sector from exerting excessive influence over the nation's healthcare sector. Private entities may prioritize their interests over those of their clientele. One possible consequence of the reliance of e-Health on the private sector is that each entity within the private sector may prioritize the prevention of misuse of its services and maximizing its benefits. An instance of this phenomenon in Iran pertains to the implementation of e-Health advancements, specifically the utilization of e-prescriptions, which are predominantly propelled by fundamental Iranian insurance policies. Insurance companies frequently compete with one another to provide superior services and increase profits rather than working together towards integrated development.

### 2.2.8 Resistance to Change: A Barrier to e-Health Adoption

Resistance to change is a significant obstacle to the progress of any innovation, including e-Health innovations. It should be noted that this challenge is not exclusive to Iran but is particularly severe in this context. Implementing e-Health technologies within Iran's healthcare system may encounter resistance from diverse stakeholders, encompassing healthcare providers, patients, and administrators. Resistance may arise due to various factors, such as a lack of familiarity with novel systems and afraid of transparency. Two doctors in this study expressed hesitations regarding using e-Health services, as evidenced by two interviews. As a result of a physician's lack of familiarity with the e-Health system, she disclosed her login credentials to her secretary. The observed behavior may be ascribed to a deficiency in comprehension regarding the system's functioning or a dearth of incentive to acquire proficiency in utilizing e-Health amenities. The confidentiality of patients may be compromised in this scenario. Concerning the fear of transparency, we can bring a significant example. The Ministry of Finance and Taxation of Iran used the patients' payment

through the point of sale (POS) to calculate the doctors' income and the required amount of Tax. Doctors became aware of this process and forced the patients to pay in cash. As a result of the multilateral cooperation between the Iranian Insurance Organization, the Medical Council of Iran, and the Tax Organization of Iran, the Tax Organization can easily calculate the amount of doctors' income based on the issued digital prescriptions. This issue also exists in private pharmacies, and the tax department quickly calculates the amount of income of pharmacies based on the number of digital prescriptions processed. This transparency is unfavorable to many stockholders, and for residents to change is inevitable.

Overall, there are several unique challenges and sociocultural factors that affect the evolution and implementation of e-Health in Iran. The lack of a robust legal framework for e-Health data protection restricts the unique cultural approach to data privacy within Iran's healthcare system. Furthermore, international sanctions severely impede technological growth and inhibit Iran's ability to collaborate and share knowledge with the global scientific community. Due to migration trends and economic difficulties, the country may also confront a critical future shortage of medical specialists. This shortage, exacerbated by international sanctions and population growth through both legal and illegal migration, puts significant pressure on the country's healthcare ecosystem. Consequently, patients often face long wait times in the medical centres, and long waiting time can be more annoying for patient when they need urgent medication. According to this study (13), the results demonstrated that waiting time in the emergency rooms of Iranian hospitals was higher than the national and international standards. The average doctor visit duration time in Iran has been estimated to be approximately 4.89 minutes which is relatively less than in developed countries (14). These factors underline the distinct challenges and uniqueness of Iran's e-Health evolution, thereby emphasizing the need for a context-specific strategy for health innovation in the country. Finally, it should be noted that this resistance to change is not new challenge, and this problem experienced many years ago, when former president of Iran Hasan Rohani tried to establish medical records in Iran, but it was unsuccessful due to the resistance to change in Iran. According to Financial Tribune [1] "The Electronic records have been opened for almost half of the 80 million population so far, while only 10% of all medical centers and doctor's offices use electronic records system."

[1]Financial Tribune in 2014 is a non-governmental newspaper in Iran opened in 2014. Its purpose is to cover a variety of political, economic, technology, and social stories. Link to News

## 2.3 Healthcare stakeholders Analysis in Iran

The healthcare ecosystem in Iran, particularly the e-Health sector, involves a variety of stakeholders, such as governmental bodies, private organizations, and individual contributors. This study focuses on the primary stakeholders who directly and significantly influence e-Health services, which refers to using information and communication technologies for health. This research does not consider specific governmental organizations, like the nursing system organization, legislative assembly, forensic doctor organization, special patients support association, and the labour and social security department. Their exclusion is because their impact on the e-Health system is not direct and significant. This research underlines the importance of private insurance companies as pivotal forces in advancing e-Health services, such as electronic prescription, in Iran. Also, we consider individual stakeholders' active involvement and feedback, such as doctors and patients, as crucial for improving the existing e-Health system. For more efficient analysis, stakeholders have been divided into three groups: individuals (shown in the table 2.1), government institutions and healthcare providers (shown in the table 2.2), and insurance providers (shown in the table 2.3). The stakeholder type column in stakeholder tables determines to which sectors, including public and governmental or private, our specific stakeholders belong. The governmental sectors are policymakers, make decisions about healthcare services, and monitor all healthcare activities by public and private sectors. The public type means that a stakeholder uses the governmental budget, consisting of residents' taxes, to provide services for the residents. At the same time, the private sectors are self-funded and provide services to make money under governmental sector supervision and monitoring. The geographical coverage column determines how much the stakeholders' activity area is scaled. This study provides a detailed account of each group's various roles and primary responsibilities, facilitating a focused examination of those with the most significant potential to influence the future of e-Health in Iran.

| **Entity** | **Stakeholder Type** | **Geographical Coverage** |
|---|---|---|
| Patients | Individual | - |
| General Practitioners | Individual | National |
| Specialists | Individual | Urban areas |
| Healthcare IT Specialist | Individual | National |

**Table 2.1:** Individuals

| Entity | Stakeholder Type | Geographical Coverage |
|---|---|---|
| Health Ministry and Medical Education (MOHME) | Governmental | International |
| Medical Council of the Iran | Governmental | National |
| Public Hospitals | Public | National |
| Private Hospitals | Private | Big cities |
| Health Homes | Public | Rural areas |
| Private Healthcare Startups | Private | National |
| Medical Labs | Private and Public | Urban areas |
| Pharmacies | Private and Public | Urban areas |
| Medical Imaging Service Centres | Private and Public | Big cities |

**Table 2.2:** Government Institutions and Healthcare Providers

| Entity | Stakeholder Type | Geographical Coverage |
|---|---|---|
| Basic Health Insurances | Private | National |
| Supplementary Health Insurances | Private | International |

**Table 2.3:** Insurance Providers

### 2.3.1 Ministry of Health and Medical Education

The Ministry of Health and Medical Education (MOHME) is a key governmental stakeholder in Iran that carries a crucial role in determining the trajectory of the healthcare industry. The stakeholder in question oversees the supervision of health policies, strategies, and plans to ensure their alignment with the nation's developmental objectives. The MOHME has implemented a meticulous monitoring system that oversees both the private and public healthcare sectors. However, its level of control over private stakeholders, such as private hospitals and e-Health startups, is comparatively less direct. The oversight of e-Health sectors, including electronic prescription (e-prescription) and medical data management systems, falls under its jurisdiction. The task of compiling, scrutinizing, and disseminating healthcare data is undertaken with the aim of facilitating informed decision-making and raising public awareness. Moreover, MOHME assumes a pioneering role in the formulation and execution of e-Health programs and digital health amenities, guarantee-

ing universal accessibility and safeguarding confidentiality. The MOHME is the sole entity with a global range of operations and bears the duty of engaging in information sharing with the World Health Organization (WHO) and other nations.

### 2.3.2 Medical Council of Iran

The Medical Council of Iran is the official governing and supervisory entity responsible for the licensure and regulation of healthcare practitioners in Iran. It is the overarching regulatory body responsible for supervising bilateral or multilateral collaborations between various stakeholders, such as insurance companies, healthcare providers, and patients. The Medical Council of Iran serves as the primary regulatory authority for healthcare professionals, responsible for monitoring the activities of licensed health practitioners, including physicians, to ensure their adherence to legal obligations regarding maintaining professional competence. This regulatory body possesses the authority to issue cautionary notices to physicians and select healthcare professionals and temporarily or permanently rescind their licensure to engage in their respective practices. As an example of the Medical Council of Iran's activities, we discovered through one interview that a general practitioner delegated passwords for online prescriptions to her secretary, and the secretary misused the authentication information. The Medical Council of Iran temporarily suspended the doctor's license because she had given authentication information to someone else. Another example of the Medical Council of Iran's activities is that some healthcare professionals were dissatisfied with online services since the council monitored various activities, such as the number of patients visited daily. This monitoring ensured that doctors spent sufficient time diagnosing patients' health problems. Another example of this stakeholder's activity can be seen in its collaboration with the Tax Administration. The Tax Administration calculates the yearly tax based on the patient's visit payment via the Point of Sale (POS) machine. Some healthcare providers refuse to use POS machines and require patients to pay in cash. The Tax Administration has access to the number of digital medical prescriptions issued due to collaboration between the Tax Administration and the Medical Council of Iran, and healthcare providers cannot avoid taxes. This stakeholder is also responsible for handling public complaints from doctors, nurses, and medical centers on either online or offline platforms.

### 2.3.3 Public Hospitals

Public hospitals serve as pivotal stakeholders in the public healthcare sector, offering a range of health-related services including urgent care, consultations with general practitioners, specialists, psychologists, medical testing, imaging services, and surgeries. At least one public hospital is present in each province of Iran. To graduate from medical universities, every doctor must participate in an 18 to 24 month low-salary traineeship at public hospitals, depending on their specialty. This mandatory traineeship, instituted by the MOHME, serves to augment the quantity of healthcare providers in public hospitals, particularly in underserved and remote provinces. This strategy not only enhances the doctor count in public hospitals, but it also enriches the learning experience of medical students. Importantly, the choice of traineeship location is not left to the medical students; the selection is randomized. Thanks to public hospitals, most legal residents in Iran can access essential healthcare services either for free or at a minimal cost. To qualify for these public healthcare services, patients must be covered by Iranian Basic Insurance, which encompasses Social Security, Iranian Health, and Military Personnel Insurance. The inclusion of this stakeholder is necessary as e-Health services are integrated into various aspects of the workflow in public hospitals. For example, in an interview conducted with Dr. Mohammad Mehdi Javaidan on 22 October 2022, it was revealed that a dental imaging center in a public hospital now uploads dental images to an online system, thereby eliminating the need for printed radiology images. In addition, e-prescriptions have become widespread in public hospitals. Given the relatively limited oversight of the Ministry of Health and Medical Education and the Medical Council of Iran over the private sector, particularly private hospitals, there may be some resistance to the adoption of e-Health systems. Such hesitancy could arise from concerns about the enhanced transparency that e-Health systems could impose on operational practices. As a result, the study of e-Health implementation might be more feasibly and reliably conducted within the public hospital sector, where these systems are likely more pervasive and their effects more readily observable.

### 2.3.4 Health Homes

Based on the statistical data provided by the World Bank in 2021 [1] and a study (15), we can see that approximately one-quarter of the Iranian population resides in non-urban regions, defined as rural areas. The Iranian Ministry of Health and Medical Education has

[1] https://genderdata.worldbank.org/indicators/sp-rur-totl-zs/?gender=total

made efforts to provide healthcare services to these rural inhabitants by establishing rural health Houses (16) (shown in figure 2.4). Health Houses typically offer primary healthcare services, such as preliminary medical assessments, limited dispensation of medications from an internal pharmacy, and administration of injections. However, these facilities typically lack access to specialized diagnostic equipment like electrocardiography and ultrasound, commonly utilized by medical professionals. When necessary, the Health House refers patients to public hospitals located in the nearest cities. Currently, all referrals and the presentation process are paper-based. The general practitioner at the Health House writes a referral letter detailing the initial diagnosis and necessary follow-up treatments, and the patient then personally delivers this letter to public hospitals in cities. Individuals residing in rural areas are entitled to use the designated Basic Iranian insurance, Iranian Health insurance, at no cost. This insurance targets low-income individuals and enables rural residents to access medical services in public sectors, either for free or at significantly reduced prices. We consider this stakeholder necessary in our research investigation, as we aim to evaluate the country's infrastructure in the third phase of our research methodology. Currently, the adoption of e-Health services is not mandatory in Iran. However, according to interviews we conducted, it is anticipated to become mandatory within the next two years. The compulsory adoption of e-Health services within a nation depends on the adequacy of the country's infrastructure. The e-Health implementation in rural areas of Iran can facilitate the communication process. e-Health developments in these areas allow healthcare providers to have real-time sharing of patients' medical records easily. In the current healthcare service, there is no system for maintaining medical records or for tracking patients' health in these areas. The e-Health services, such as e-prescription and online medical records on insurance websites, can significantly enhance the quality of healthcare services in these parts of Iran. Therefore, this issue warrants evaluation in the third phase of the research methodology.

**Figure 2.4:** Health Homes and Two Patients Source Link

### 2.3.5 Private Hospitals

The healthcare system in Iran comprises two distinct sectors: public and private. While the public sector provides low-cost healthcare services, it struggles with extended waiting times due to Iran's ever-increasing population (13) (14). Conversely, despite being more costly, private healthcare facilities provide superior quality services, reduced waiting periods, cutting-edge medical equipment, and high-end amenities. The high cost of private healthcare necessitates additional insurance coverage over and above the basic Iranian insurance, which only covers a minor portion of treatment expenses in private hospitals. Therefore, non-compulsory supplementary insurance, available in various forms, plays a crucial role in making private healthcare accessible for many. Private hospitals, although typically smaller in size than public ones, are significant stakeholders in Iran's healthcare system. Although public hospitals tend to employ e-Health services in various sectors due to the higher supervision of the Ministry of Health and Education, accessing and analyzing public hospitals was more challenging due to the strict permission and managerial approval needed for conducting interviews. Conversely, private healthcare providers were more accessible and were more receptive to interview requests, demonstrating their openness to engagement and potential collaborations.

### 2.3.6 Private Healthcare Startups

In the growing trend of digital health solutions, a group of emerging startups in Iran is making substantial strides. Innovative companies developing applications are transforming the private healthcare sector, although thier benefits are sometimes neglected by both policymakers and end users(Doctors and Patients) (17). The startups under investigation are essential for our research, as they offer tangible benefits to patients and healthcare providers. Based on interviews, we found that users and healthcare providers have shared positive experiences with these applications. Significantly, the benefits are not restricted solely to Iran. Implementing health technology solutions is yielding benefits to Iranian users abroad. SnappDoctor (subsubsection 2.3.6.1) and DrSaina (subsubsection 2.3.6.2) are two pioneering companies in the field. These startups stand out by providing online healthcare services that bridge the gap between patients and healthcare services, highlighting the beneficial impact of these digital solutions.

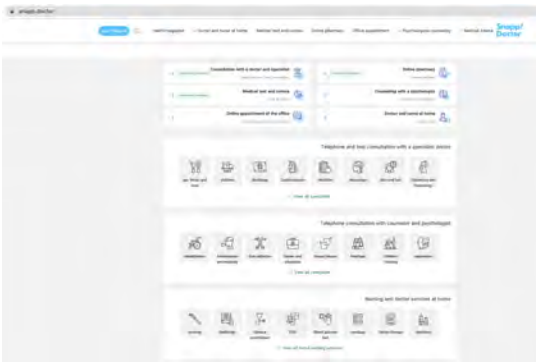
#### 2.3.6.1 Snappdoctor as a Well Known Private Healthcare Startups

SnappDoctor [1] is a telemedicine platform established by Iran's private healthcare industry in 2020, according to the domain's establishment date, which was 2020-04-29. It was created to increase access to e-Health services, especially for people living in underserved and disadvantaged areas. The platform offers various medical services, such as lab tests, over-the-counter and prescription medicine delivery, online doctor consultations, and medical advice (shown in figure 2.5) [2]. Patients had found SnappDoctor to be a popular option in Iran and among Iranians living abroad, especially during the COVID-19 pandemic when people hesitated to visit medical facilities in person. To save time and money on travel, patients can use the platform to quickly connect with healthcare providers via video consultations, audio calls, or text messaging. Thanks to various connection options, even those without access to high-speed Internet in underserved areas can use this platform. Each platform that operates commercially online in Iran needs to obtain a certificate (Namely Enamad in Persian) from the Iranian Ministry of Industry and Trade [3]. As an online healthcare platform, SnappDoctor also has this certificate, indicating that SnappDoctor is a certified service provider. The Iranian Ministry of Industry and Trade evaluates the reliability of platforms, rating them on a scale of one to five. Each platform must publish this score on its website.

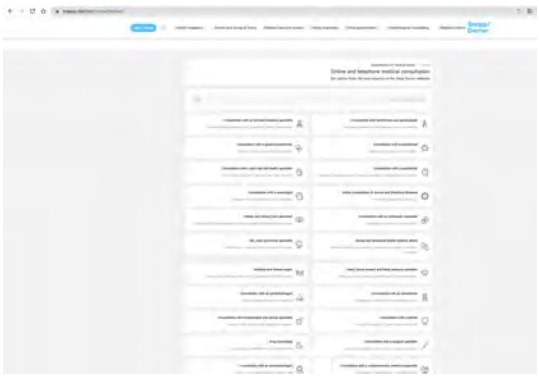
[1] https://snapp.doctor/

[2] Google Translate website is used to translate the texts in these screenshots since the SnappDoctor platform is not a multi-language website and provides services in the Persian language.

[3] https://enamad.ir/About

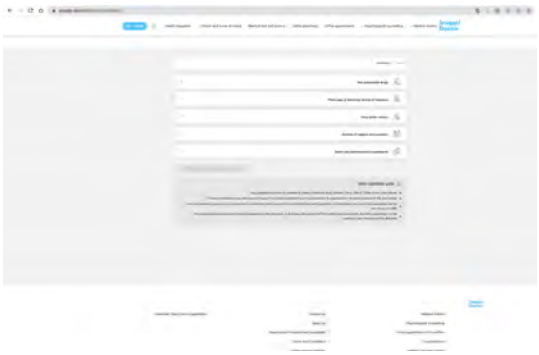


**(a)** Snapp Doctor Main page

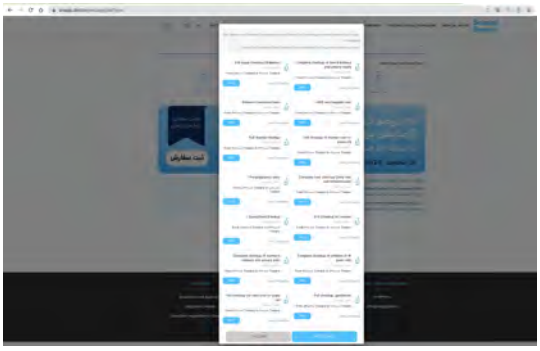


**(b)** Snapp doctor consultation page

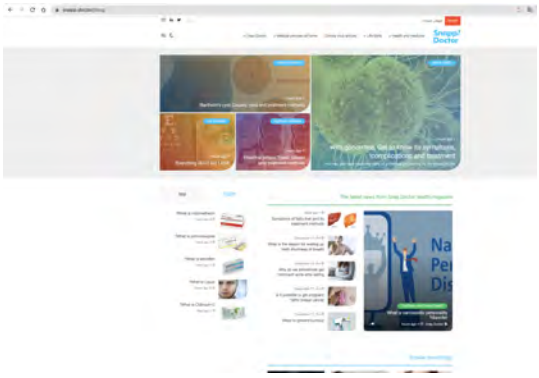
**(c)** Snapp doctor psychology page



**(d)** Snapp doctor pharmacy page



**(e)** Snapp doctor health education page



**(f)** snapp doctor blog page

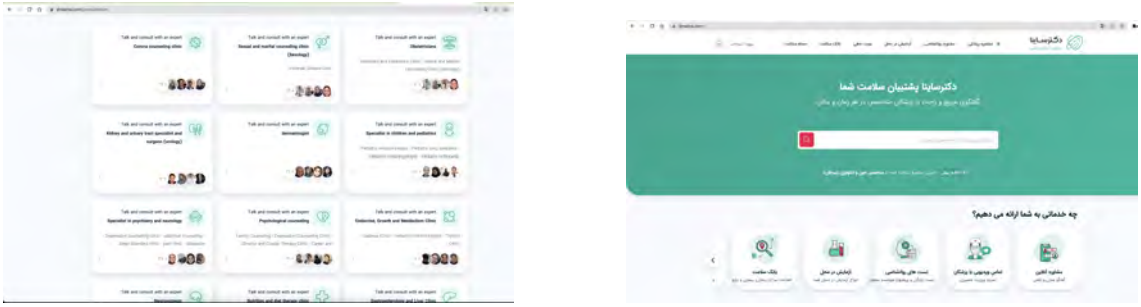
**Figure 2.5:** Snapp Doctor Website

#### 2.3.6.2 DrSaina as a Well Known Private Healthcare Startups

DrSaina [1] is an all-encompassing digital healthcare platform established to offer healthcare services to the Iranian population via the Internet. Similar to SnappDoctor (discussed in

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

subsubsection 2.3.6.1), this platform offers various online services to patients and enhances accessibility to healthcare services for a wide range of individuals, particularly those residing in remote and underserved regions. The DrSaina e-Health platform can be accessed through its website (shown in figure 2.6) [1].



**(a)** List of Specialist

**(b)** Main webpage

**Figure 2.6:** DrSaina Website

### 2.3.7 Medical Labs

Medical Labs represent a significant stakeholder in the recent e-Health implementation in Iran, engaging in two distinct ways. Firstly, they collaborate with online e-Health startups like Snappdoctor and DrSaina. These platforms allow patients to order various self-check medical tests without a prescription, either from their homes or in the labs. The Labs then conduct these tests and publish the results on the platforms. However, this development presents a potential drawback, as revealed in one of our interviews. There is a concern that this convenience might encourage unnecessary overuse of testing by patients, especially since neither basic Iranian insurance nor supplementary insurance covers the cost of self-administered tests (medical tests without prescription). Separately, Medical Labs are now also integrating with an online prescription system. This system allows doctors to prescribe medical tests using the patient's national ID code, and the labs then upload the results online for doctors to view. It must be noted that while some medical labs use this online result delivery, most still print the test results for the patient, and then the doctor adds a summary of these results to the patient's basic Iranian insurance record. This demonstrates that Medical Labs play a significant role in the ongoing e-Health implementation, especially in the field of e-prescription, in Iran. There are two types of Medical Labs in Iran. Public Medical Labs are located inside public hospitals, while private ones provide services inside

[1] Google Translate website is used to translate the texts in these screenshots since the SnappDoctor platform is not a multi-language website and provides services in the Persian language.

private hospitals and various parts of cities. Medical tests in public medical labs in Iran are either free of charge or very low cost with a prescription for insured patients, while private medical labs charge the patients for their services. It is worth mentioning that all medical labs are located in urban areas.

### 2.3.8 Pharmacies

Pharmacies play a significant role in the evolution of e-prescriptions in Iran. This progression, driven by insurance companies, aims to eliminate errors and prevent potential misuse. Through various insurance systems, doctors can issue prescriptions, which pharmacists then access using the patient's national code to dispense the medication. One common complaint about this system from pharmacists is the need to retrieve prescribed medicines from multiple insurance portals instead of one consolidated system. Another progressive aspect of Iranian e-Health is the capability of pharmacies to search for specific medications across other pharmacies quickly. This functionality allows them to inform patients where they can find currently unavailable medications. However, this system's adoption is still limited, with only a tiny percentage of pharmacists benefiting from it, as highlighted in an interview with a pharmacist, Dr. Mohammad Ali Abu Torabi. Pharmacies in Iran fall into two main categories: public and private sectors. Both face substantial challenges due to United States sanctions on Iran, which complicates the import of necessary medications and leads to accessibility issues for patients. The Ministry of Health and Medical Education allows only public pharmacies to distribute vital and rare medications since this ministry can have better monitoring of this sector. This strategy aims to ensure the equitable distribution of these crucial medicines, despite the challenging circumstances. It is also noteworthy that some pharmacies in Iran, particularly those in the public sector, offer round-the-clock services in major cities.

### 2.3.9 Medical Imaging Service Centres

Medical Imaging Service Providers are a significant stakeholder in the development of e-Health in Iran. These diagnostic service providers are divided into private and public sectors. Due to the private sector's relative freedom (Exemption from the imposed sanctions by the United States of America) and budget in importing medical devices, private Medical Imaging Service Centres typically possess more advanced medical devices than their public counterparts. Public Medical Imaging Service Centres frequently face long waiting lists

(13). This situation often forces patients to turn to private service providers for more immediate assistance. It must be noted that basic Iranian insurance does not cover the high cost of medical imaging in private medical sectors, and patients are supposed to pay either out of their own pocket or use supplementary insurance, like SOS insurance. An essential point about payments for medical imaging medications is that supplementary insurance might have different coverage rules based on the doctor who prescribed the prescription and covers a higher proportion of the cost when a specialist fills a prescription. Similar to the procedure adopted by pharmacies, doctors can issue prescriptions for diagnostic services at Medical Imaging Service centers through various insurance systems, including Social Security insurance, Iranian health insurance, and Iranian military insurance. This innovation reflects the engagement of Medical Imaging Service Providers in the evolution of e-Health in Iran.

### 2.3.10 Patients

Patients, as vital stakeholders in the healthcare system, mainly interact with Iran's e-Health services indirectly. Most developed e-Health services aim to facilitate the diagnosis and treatment processes for healthcare providers, including doctors and pharmacists. This approach enhances the precision of diagnostic and treatment services, minimizes errors, and ultimately benefits patients. One example is the e-prescription systems developed by insurance companies. This innovation simplifies the prescription process for doctors, pharmacists, and medical diagnostic centers. While patients may perceive this change as simply a transition from paper-based to online prescriptions, the system has numerous indirect impacts on them. It speeds up the diagnosis procedure, helps prevent incorrect medication dispensing, promotes the use of medication guides, enhances medication safety by checking for potential drug interactions, and maintains a national record of medical history. Thus, even though patients' engagement is not direct, they are significantly affected by these e-Health developments. We include this stakeholder in our following investigations since we believe any encasement by the probable solution for potential challenges in e-Health services can affect the patients, and their satisfaction is a part of our investigation.

### 2.3.11 General Practitioners

General Practitioners (GPs) are essential stakeholders in the Iranian e-Health system. Unlike in some countries, where patients do not have the option to choose between visiting a GP or a specialist for their first visit, patients in Iran have the freedom to make this

decision. In major cities like Tehran, lengthy waiting times to see specialists often prompt patients to visit General Practitioners first. These GPs can then provide a referral, expediting the patient's visit to a specialist if necessary. Moreover, in Iran, General Practitioners are not confined to hospital workspaces and can maintain their own offices. An interesting issue regarding GPs and insurance coverage is the discrepancy in reimbursement rates between services prescribed by GPs and those prescribed by specialists. For instance, supplementary insurance, as we mentioned before, may cover a smaller portion of the cost of a medical imaging service requested by a General Practitioner as compared to a specialist. This discrepancy could be perceived as unfair and may inadvertently encourage patients to visit specialists directly to access more affordable diagnostic services. Each GP has its own medical identification number, and patients can verify the validity of their certificates through the Medical Council's website [1].

### 2.3.12 Specialists

Specialists serve as another important stakeholder in the Iranian e-Health system. Accessibility to specialists is primarily concentrated in urban areas, leading to limited access for rural populations, which account for nearly a quarter of Iran's total population. According to this study (18), the distribution percentage of specialists in the year 2018 is illustrated in the figure 2.7, which shows that more than one-fifth of specialist were in the capital of Iran in the year 2018. The migration of specialists to developed countries, driven by lower income and high work pressure in developing countries, further strains Iran's healthcare system. Also, specialists tend to gravitate towards larger cities to increase their income rather than servicing rural areas or smaller cities. As vital stakeholders, specialists utilize various e-Health services in Iran. They use online prescription systems and input medical records into insurance portals, creating comprehensive patient medical histories. Importantly, specialists maintained their own records of patients' histories, whether in paper-based documents or digital formats such as Microsoft Excel, before the e-Health development by insurance companies. It should be noted that all Microsoft Products are forbidden in this country due to US sanctions, but Iranian users might use this software by changing their IP address to an IP outside of the country. Specialists have to make records of patients since their treatment might be more time-consuming and take months or even years, and they need to be aware of previous medications by themselves. These records

[1] https://membersearch.irimc.org/ Note: Due to recent cyber attacks to most of governmental websites in Iran, they are just accessible by Iran IP from inside of country.

are critical in tracking previous diagnoses and medications, especially for patients requiring long-term treatment. Furthermore, specialists have found ways to extend their reach beyond urban areas. They leverage online portals like SnapDoctor and DrSiana to provide services to patients nationwide conveniently. These recent advancements in e-Health services by private startups have opened up new avenues for specialists to generate income and offer more convenient consultations for patients in smaller cities or rural areas.

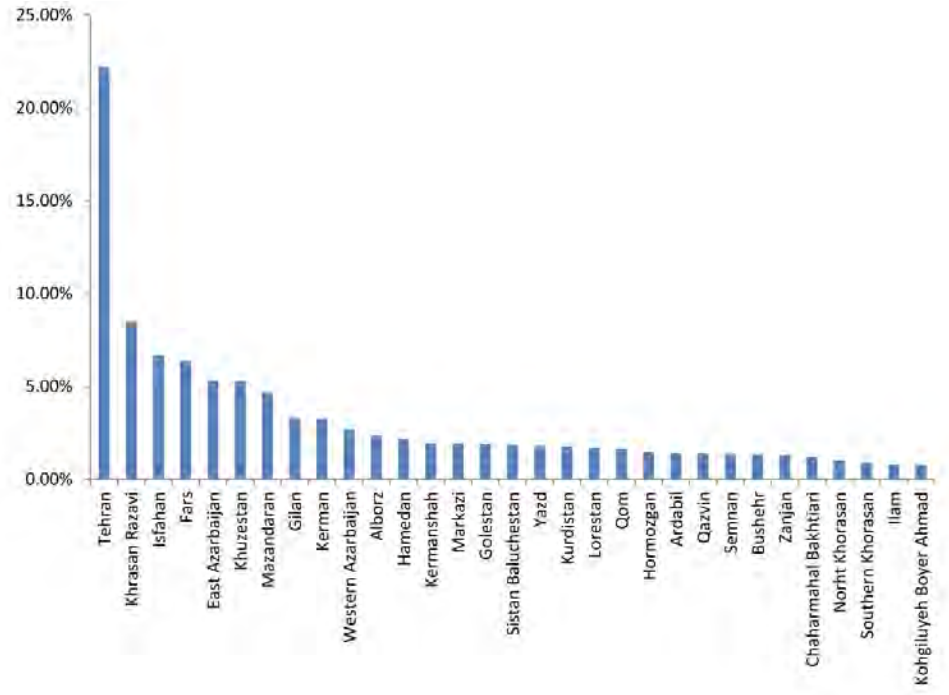



**Figure 2.7:** Distribution Percentage of Specialist over different Cities in Iran Source Link

### 2.3.13 Healthcare IT Specialist

Findings from our study reveal that most e-Health implementations in Iran are propelled by healthcare startups and insurance companies, primarily private entities. The Ministry of Health and Medical Education oversees all e-Health developments in the country, safeguarding the rights of both patients and healthcare providers. As the Ministry is mainly composed of individuals with medical backgrounds, it employs healthcare IT specialists to facilitate this oversight. Due to the sanctions imposed on Iran by the United States, Iranian policymakers often find themselves compelled to establish the necessary IT-related facilities and infrastructure independently, predominantly utilizing domestic technology. Therefore, healthcare IT specialists play a pivotal role in the implementation of e-Health solutions in Iran.

### 2.3.14 Basic Health Insurance Providers

Basic Health Insurance Providers emerge as our study's most critical e-Health stakeholders. Based on various interviews, these providers drive nearly all e-Health development in Iran. They comprise three major insurance companies: Social Security Insurance (a private agency), Iranian Health Insurance (a private agency), and Military Insurance (A governmental insurance agency). Each agency has played a crucial role in promoting e-Health implementation. Before the recent shift towards e-Health, all these agencies provided booklets (pictures of which can be found in figure 2.8) to their insurers in which doctors noted required drugs and diagnostic tests for patients. The insurance expiration date was manually written on these booklets and checked by the doctor's secretary. These agencies were prompted to digitize the insurance healthcare system for various reasons; chief among them was preventing misuse of insurance benefits, as highlighted in many interviews. The transition to a digital system allowed for stricter and more precise control over-prescribed medications. For instance, they could question doctors about an unusually large prescription within a specific time frame. Before e-Health development, a patient could obtain all prescribed medications, such as a month's painkillers, in one pharmacy visit. Now, patients must collect their medication in two separate fortnightly visits. This shift not only aids in equitable medicine distribution during shortages but also potentially saves insurance providers' costs, as patients may no longer need the medication after the first two weeks. According to the patient's medical records, insurance providers can also scrutinize prescriptions for rare and expensive medications if alternative treatment options have not been explored. Doctors are then required to justify their prescriptions. Thanks to online prescription systems and patient healthcare record management systems developed by these three insurance agencies, insurance companies can monitor activities to protect their interests and prevent misuse, such as over-prescribing medication. One notable aspect of e-Health development is the need for an integrated system across these insurance agencies. Each agency has its system and focuses on enhancing its portal, leading to competition rather than collaboration. This approach can create difficulties for pharmacists and doctors, who are forced to use multiple systems and waste valuable time, as reflected in several interviews. This problem can become more severe for doctors, who want to retrieve and check the patient's medical records, for patients who changed their Insurance, and medical records are on different portals.

**(a)** Social Security Insurance Booklet Source

**(b)** Iranian Health Insurance Booklet Source

**(c)** Military Insurance Booklet Source

**Figure 2.8:** Basic Health Insurance Providers' Booklet in Former Non-digital System

### 2.3.15 Supplementary Health Insurance Providers

All legal residents of Iran must have basic Iranian insurance coverage provided by either Social Security Insurance, Iranian Health Insurance, or Military Insurance. This basic insurance covers healthcare services offered by public healthcare entities, including public hospitals and health homes. However, to access the private healthcare sector, patients have two options: they can either pay out-of-pocket or utilize Supplementary Health Insurance. This type of insurance covers the costs of diagnostic and treatment services in private-sector facilities. Some companies offer Supplementary Health Insurance as part of their employee benefits. For instance, bank employees may be eligible for bank insurance, a form of Supplementary Health Insurance. It is important to note that all Supplementary Health Insurance providers are private entities, and none have participated in e-Health implementations actively to date. However, Supplementary Health Insurance Providers are significant stakeholders in our research because they have begun collaborating with basic insurance providers to benefit from e-Health advantages in their own companies.

## 2.4 Mendelow Diagram

To simplify the analysis, it was essential to identify and analyze the stakeholders directly and significantly impacting e-Health services. Using the Mendelow Diagram, we can prioritize stakeholders based on their power— their ability to influence our project's strategy or resources— and interest— their level of investment in the project's success (shown in figure 2.9). Our project affects an extensive list of individuals and groups, some of whom have the power to propel or obstruct its progress. The Mendelow Diagram is helpful in prioritizing these stakeholders and facilitating our project management efforts. According to our conducted analysis, Basic Health Insurance Providers, the Ministry of Health and Medical Education, General Practitioners, Specialists, and Healthcare IT Specialists fall under the category of stakeholders with high power and high interest. This categorization is because basic health insurance providers, the primary developers of most e-Health implementations in Iran, have significant power to directly influence the system. These providers also exhibit the highest interest as e-Health development can prevent various system misuses and bring about more non-financial and financial benefits for them.

The Ministry of Health and Medical Education, responsible for supervising and monitoring all healthcare-related development in the country, can alarm basic health insurance providers about their activities if they find them misaligned with the country's development goals. This ministry is also responsible for providing annual reports to the president of Iran about any challenges or advancements in the healthcare system, a responsibility that serves as a motivator, making this ministry interested in any e-Health innovation.

Both General Practitioners and Specialists, being at the forefront of using e-Health, hold high power in Iran's healthcare ecosystem. If they deem the e-Health innovations unnecessary, they could refuse to use these developments, indicating their substantial influence. These professionals also demonstrate high interest in such advancements, as any innovation in healthcare can streamline their work.

Pharmacies also have a significant interest and influence on e-Health providers. They express interest in e-Health development as it simplifies their work and helps them prevent human errors in medicine preparation. Their feedback on the e-Health system is essential, and the system can be immediately disrupted if they find some e-Health development, such as e-prescription, useless.

Healthcare IT specialists also wield substantial power and interest due to their role in developing domestic IT software. Private healthcare startups fall into the category of high

interest but low power. They can profit from their services, so they are interested in e-Health development as it facilitates their work. However, these startups require various permissions to provide services, limiting their direct influence on e-Health developments. For example, only two private healthcare startups, Snappdoctor and Drsaina, are permitted to sell prescription-required medicines, indicating the limited power of these startups in impacting the e-Health system.

Supplementary insurance companies also exhibit high interest but low power in the recent e-Health development in Iran. They can benefit from misuse prevention efforts initiated by Basic Health Insurance providers, but their power is insufficient to significantly impact e-Health services.

Primary users such as Public Hospitals, Private Hospitals, clinics, health homes, and medical labs all use the e-Health developments in Iran. Their power as primary users is relatively high, and their resistance to change could easily disrupt the entire e-Health system. However, they benefit less from the outcomes of e-Health than other stakeholders like General Practitioners and Basic Insurance providers. For instance, a clinic might perceive the recent e-Health development as a mere shift from printing to digital test results rather than a significant success in updating to patient health records.

Finally, patients hold the slightest interest and power. They cannot leverage insurance services if they choose not to use e-Health Services, when doctors prefer to use e-prescriptions. Their interest in e-Health development is limited, as their engagement with the system is entirely indirect and resulting benefits from e-Health is not tangible for them.

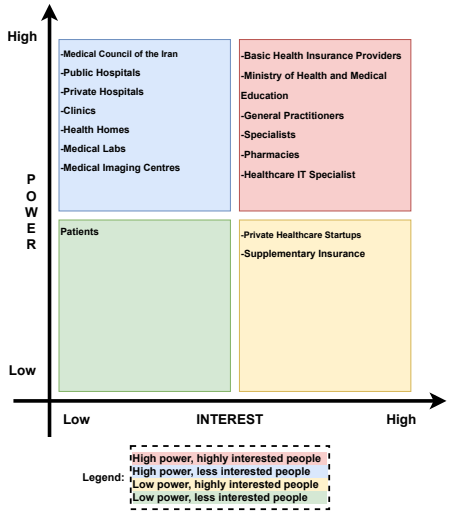



**Figure 2.9:** Mendelow's Matrix for Engaged stakeholders

# 3

# Need Assessments

In the previous chapter, we investigated the current status of e-Health development in Iran, including unique challenges of implementing e-Health systems in Iran as an isolated developing country. In this chapter, according to our methodology, we assess the critical stockholders' requirements in the second phase of our research to address Research Question 2 which is *"How can we identify the needs and requirements of stake- holders in the health sector to design appropriate user-centered e-Health solutions within a complex context, such as Iranian healthcare system?"*. As we discussed in methodology in details (section 1.2.2), need assessment consists of two iterative steps(4). In this chapter, we address the initial step of need assessment, which results in a list of stakeholders' needs and requirements, as expressed by the end-user (4). These expectations could be unique and significantly influenced by cultural norms specific to Iran's population. This chapter presents an analysis of the results obtained from our interviews, with a particular emphasis on the need assessments. The iterative method of comprehending the operational objectives of users and existing limitations is emphasized as a crucial aspect of the requirement engineering procedure. The adopted ICT4D methodology that we discussed in section 1.2 facilitates comprehension and analysis of the problem domain, which is imperative in devising efficacious resolutions. The iterative nature of this process guarantees that comprehension of the problem domain is consistently enhanced and revised (4). The process of exploring the solution space is a crucial subsequent phase of requirement evaluation that entails establishing priorities for feasible and desirable use cases. This process yields a catalog of potential project(4) for different use cases. The identification and ranking of use-case scenarios will be conducted during the fourth phase of the ongoing research, as outlined in the project methodology.

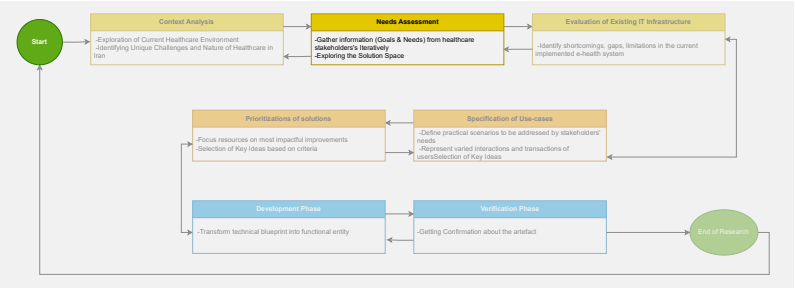



**Figure 3.1:** Need Assessment (Second Step of the Methodology)

## 3.1 Types of Stakeholder Awareness

Stakeholders awareness can be seen as an essential factor which determines Stakeholders' requirements from their points of view. To gather information and determining their requirements from their points of view not from outside of the system, we conducted semi-structural interviews. Stakeholders who took part in our semi-structural interviews have different levels of awareness of a problem and its possible treatments/solution (different levels shown visually in the figure 3.2). At the lowest awareness level, a stakeholder was not aware of the problem nor of the need of a treatment(19). As an example, a patient who engaged in e-prescription system indirectly is not aware of problems resulting from hand-written prescription or this patient does not feel any need for addressing problems resulting from hand-written prescription, and complained about existence of new e-Health developments. At the second level of awareness, a stakeholder is aware of an improvement possibility but is not interested in actually carrying out the improvement (19). For instance, Ministry of Health in Iran is aware of problems resulting from dependency of basic Iranian Insurances and lack of integrated e-Health portals, but they do not care. Third group of stakeholder's awareness belongs to group of stockholders who are aware of the improvement possibility and desire it. However, this group of stockholders may have no time or no money to realize this desire, or the desire is not strong enough to commit the time or money needed to achieve the desire (19). In this case, the stakeholder desires an improvement but has not set it as a goal to achieve. For example, pharmacies are aware of sever medicine shortage in the country, and they aware that keeping global database between country's pharmacies can effectively help. However, they do not have time to tackle this problem manually. As another example, patients are the stackholders who significantly suffer from medicine shortages and have to visit several pharmacies his/her hometown or even neighbour cities to find the rare prescribed medicines. Patients desire either long-term improvement, like

impotent more medicines from foreign countries, or short solution like a updated database which inform them where they can find required medicines. However, their effect and power as we also discussed in Mendelow's Matrix in section 2.4 is not such strong to to reach desired goals. In this chapter, we define a stakeholder goal as a desire for which the stakeholder has committed resources. The stakeholder is willing to achieve this goal and has committed money and/or time to achieve it (19). All stakeholders have finite resources, and only a few desires will be promoted to the status of goal.

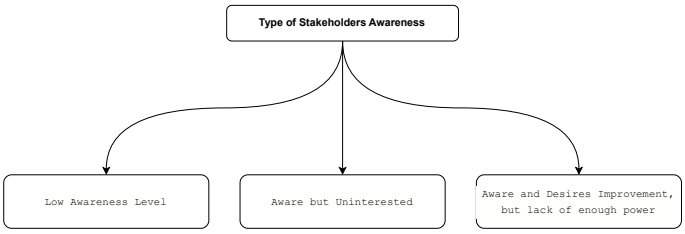



**Figure 3.2:** Types of Stakeholder Awareness

## 3.2 Stakeholders' Desires and Conflicts

Goals refer to the desired outcomes for which resources are allocated. Engineers and researchers in design science must possess knowledge about human desires, as stakeholders obtain artifacts to aid in achieving their objectives. In the absence of human desires, the creation of artifacts would become unnecessary, leading to a potential decrease in demand for engineers and design science researchers(19). Sometimes, a stakeholder's desires and objectives might conflict with those of others. In this situation, stakeholders with greater power prevail and reach their goals. The presence of conflicting desires could potentially serve as a basis for terminating a design project or modifying its objectives (19). In this research, different conflicts exist between stakeholders' objectives. For example, each Iranian Basic Insurances, as a significant stakeholder in recent e-Health development, prefers to have its own portal to provide services and strives to gain competitive advantages. This stakeholders' goal is to prevent misuse of insurance services and attract as many customers as possible in the private sector. On the other hand, General Practitioners and Specialists are two other important stakeholders seeking e-Health services that simplify their work. Various e-prescription portals by insurance companies with different settings are annoying and distracting for them. As we can see, the desires and objectives of these stakeholders differ and are in conflict, and insurances prevailed and there exists various insurance portals.

## 3.3 The Initial Iterative Step in Need Assessment

Understanding and expressing the needs and goals of the stakeholders is the first iteration step in the need assessment phase. It can be challenging to define stakeholder's information needs, particularly when a stakeholder has a limited understanding of ICTs or "information needs" as a whole (4). In contrast, it is challenging for an outside ICT4D researcher or developer to comprehend the operational objectives, work processes, and activities of the users. We conducted semi-structured interviews with healthcare professionals to gather their experiences in order to address these worries.

### 3.3.1 Doctors' Needs and Objectives

Within the wider scope of e-Health advancement, general practitioners and specialists are identified as significant stakeholders with high levels of influence and interest, as per Mendelow's Power-Interest Grid 2.4. The reason for their notable contribution to this industry can be ascribed to their clinical proficiency and the indispensable character of their offerings. Based on the findings of our interviews, it has been observed that a majority of medical practitioners hold the view that e-Health services, which have been created by private insurance companies, have had a positive impact on the standard of diagnosis and treatment provided to patients. Nonetheless, it is their belief that collaborating with these electronic prescription systems is not as straightforward as initially anticipated.

Dr. Mohammad Mehdi Javaidan, a recent graduate in the field of dentistry, has noted that despite his technological proficiency, the utilization of e-prescriptions can present certain difficulties. "*The user perceives the systems as needing more user-friendliness and opines that the process of searching for medication is time-consuming. we should login in various insurance websites, and each of them log out the user after a limit time for security reason and the process of login for each patient is annoying and wasting of time*". Additionally, in an interview and discussion with Dr. Nima Allahyari, a neurosurgery specialist found that each insurance portal uses its own specific coding system for medicines, medical tests, and imaging tests for e-prescriptions, leading to confusion and wasted time.

Moreover, Dr. Nima Allahyari, a specialist in neurosurgery, has highlighted that the system contains glitches that lead to erroneous prescriptions being transmitted to medical imaging facilities. "*As a consequence of bugs in e-prescription system in Iranians basic insurance, I have been erroneously perceived as a general practitioner, resulting in grievances from patients who are not covered by their supplementary insurance fully for MRI scans recommended by a general practitioner rather than a specialist.*" This specialist holds the

belief that these errors make their tasks more laborious. This specialist commenced his professional career several years ago and possessed a local database of his patients' medical documentation. The specialist noted that the medical health records of recent years are exclusively documented in the new system. Consequently, he is compelled to check the both local database and the medical records on the insurance website, a task that he perceives as onerous and time consuming.

Furthermore, he has expressed grievances regarding the requests for information made by insurance companies. As elaborated in section 2.2, Iran is confronted with a critical scarcity of medicinal supplies, resulting in an increase in expenses for medicines, particularly rare ones. According to Dr. Nima Allahyari, a specialist in neurosurgery, "*Insurance providers put pressure on medical practitioners to opt for alternative treatments whenever feasible, scrutinise doctors' prescription choices and inquiring about the rationale behind their preference for certain drugs without exploring other locally available options. These inquiries impose a significant burden on medical practitioners.*" It should be noted that this is not first time that ministry of health and insurance companies ask and put pressure on doctors to prescribe just local made medicine as we can see in IRNA news [1]. "*On Wednesday, July 5, 2018, Dr. Iraj Khodadadi stated in the medical issues review meeting: Considering the pharmaceutical threats, the possibility of preparing and using foreign drugs is a difficult task, so more detailed and complete planning should be done in the pharmaceutical field and towards the use of Internally produced drugs. He added: Doctors are obliged to include domestic medicines in the list of medicines used by patients, and if the doctor insists on using foreign medicines and not using domestic medicines, he/she should also state the reason in a written letter to this ministry.*". At times, medical practitioners may have administered alternative pharmaceuticals in advance, yet the documentation within the insurance platform fails to account for such actions, thereby impeding the ability to substantiate the necessity of exceptional medications. Moreover, doctors struggle with the instability of the Internet, often having to switch between handwritten and electronic prescriptions. This situation underscores their need for a stable network among all medical service providers. According to a doctor who preferred to remain anonymous, "Every time the government decides to shut down the Internet connection, we see a huge influx of patients at our medical centers, seeking to convert their e-prescriptions into handwritten ones. However, I can't always recall the patients' specific needs and it truly saddens me when I can't assist them...". Figure 2.3 shows a brief period of these disconnections in

[1] The Islamic Republic News Agency, or IRNA, is the official news agency of the Islamic Republic of Iran. News Link: https://irna.ir/xjtFvZ

Iran, where policymakers can shut down Internet access whenever they choose. It should be noted that Internet shutdowns are not confined to just the current year, and Iranians have experienced numerous Internet shutdowns and bandwidth limitations in the past. As another example, here is a headline from Hamshahri Online [1], "Disturbance in electronic prescribing due to internet outage: The medical system's request to the insurance companies - 'The internet has a problem; Accept the doctors' handwritten prescriptions.'" An important point to note in this part of the investigation is that all the e-Health problems mentioned in Iran's system have persisted since the initial years of e-Health development. They remain unchanged, based on our comparison of interviews conducted in November 2022 and news found in November 2021. As validation of the needs identified by stakeholders, we found a news article published around November 2021. This article, published in the semi-official Iranian newspaper Mehr News[2], states: "The technical and supervisory deputy of the medical system organization blamed the lack of adequate internet bandwidth, frequent power outages during the summer, the lack of integration of electronic prescriptions in the systems of the social security and health insurance organizations, and the presence of different drug codes as reasons for wasting doctors' time." Below, we present an itemized version of doctors' desires and expectations, which resulted from the first step of our requirements assessment:

- **Need for an integrated E-Prescription Systems:** Since each insurance company has developed its own portal for e-Health services, doctors often have to switch between various websites to prescribe medications and retrieve patient medical records. This problem can become more severe if a patient uses one insurance for a period of time and then decides to switch to a new provider. In this situation, part of the patient's health records would be located in the former insurance portal. Doctors would need to retrieve and review part of the patient's medical history on the former insurance portal, then switch to the new insurance portal to check newer medical records and prescribe electronically. It is worth mentioning that these portals use timers and automatically log out doctors after a certain period of inactivity for security reasons. Due to this mechanism, doctors have to log in to the systems for each patient, a process they find time-consuming and irritating. Another issue arising from the various insurance portals is that each one uses its own unique coding system. As

[1] Hamshahri is a major national Iranian Persian-language newspaper. Link to news: hamshahrionline.ir/x85zX

[2] The Mehr News Agency is a semi-official news agency of the Iranian government. It is headquartered in Tehran, and is owned by the Islamic Ideology Dissemination Organization. Link to news: https://mehrnews.com/xWsc4

a result, doctors sometimes have to spend additional time selecting the correct code for prescriptions of medicines, medical tests, and imaging tests, depending on the specific insurance website. Therefore, there is a need for integrated e-prescriptions to save both doctors and patients time.

- **Elimination of System Bugs:** There exist some bugs in the e-prescription system. Doctors' proficiency is incorrect, and patients have to ask doctors for edits. Since insurance coverage differs based on the person who prescribed the prescription and some supplementary insurance covers more share of treatment and diagnostic actions by specialists than general practitioners, it is important to whom and with which proficiency is prescribed. The problems resulting from these bugs are time-consuming and annoying for doctors. Here we can see a need for improvement in the e-prescription system in this country.

- **Simplified Record Keeping and the Possibility of Integration of Doctors' Local Medical Database with Insurance Medical Health Records:** Some doctors, particularly specialists, had their own digital medical records of their old patients. This is mainly owing to the fact that specialists needed patients' medical records for long-term treatment, and without these records, it seems impossible to provide accurate services. Now insurance companies provide global medical records for their patients, and doctors can keep these new databases updated. However, all e-prescription systems started seriously just two years ago, and doctors have to swipe their local and insurance databases to check their old patients' conditions. Here we can see a need for an integrated database of patients' health records.

- **Less Interference from Insurance Companies:** Basic Iranian insurance companies, which are responsible for covering medicine costs, often delay payment for foreign medicines, especially if a domestic version or a similar lower-priced version is available. They also encourage doctors to first try less expensive medicines before resorting to pricier ones. Before the advent of e-prescription, this control over prescribed medicines wasn't as strict since it was not easy, but with the advancement of e-Health, they can oversee everything, forcing doctors to justify why they prescribed a specific medicine. This occurs even when doctors, based on the patient's history of used medicines, know that a less expensive or domestic version of a medicine may not be effective. The insurance companies, however, often lack updated medical records, leading them to believe that doctors are immediately prescribing expensive and rare

medications. In such cases, doctors need to provide a clarification to the insurance company and in some case ministry of health as to why they prescribed those medications. Here again, we see that an integrated local medical database could serve as a beneficial IT solution for providing more clarification.

- **Need for an Stable Connection Between all Healthcare Providers** A network connection is essential for e-services, especially e-Health services, where immediate communication is necessary between various stakeholders, including doctors and pharmacists. Nevertheless, Iran is an isolated country with local Internet Service Providers (ISPs), all of which are under the control of policymakers. These policymakers, as discussed in this section, might shut down the entire country's internet to achieve their own goals. Despite the existence of paper-based prescriptions, which can be used during these shutdown periods, such disruptions can create severe conditions for doctors, pharmacists, and particularly patients.

#### 3.3.1.1 Doctors' Awareness regarding their needs

Most of the doctor interviewees, fortunately, had adequate awareness of the issues present in the current e-Health development. However, a small number of these doctors had unrealistic desires and needs that were not feasible. To construct effective technologies, especially in settings with limited resources, it's imperative to establish a connection that spans the cultural, physical, and linguistic barriers that may exist between developers and end-users(4). Sometimes, there exists a gap between stakeholders' ideas and the feasibility of IT solutions. This group of stakeholders cannot be categorized as unaware since they understand the challenges well. However, their proposed solutions are often far from realistic IT solutions. For example, one specialist proposed that Iran's Ministry of Health provide a smart card for each patient, with all medical health records saved for confidentiality and users' comfort. The patient would then bring this smart card to each doctor visit. This idea rooted into a sever unique challenge in Iran, which is frequent Internet shutdowns by the policymakers as we discussed in section 2.2.3. With this idea, all stakeholders, including doctors, pharmacists, hospitals, and medical lab can access the patients' medical data in offline mode. However, this solution is not feasible due to its high cost, time-intensive nature, and the technical challenge of storing extensive information on a single smart card. According to oracle website and Gartner Group [1], maximum data capacity for smart cards belongs to Optical Memory Cards, which look like a card with

[1] https://www.oracle.com/java/technologies/java-card/smartcards.html

a piece of a CD glued on top, with 4.9 Mbytes capacity. The appropriate price for this specific type of smart card is between 7 and 12 United State dollars, and each card reader for them costs between 3,500 and 4,000 United State dollars. This cost is fully behind the Iranian medical service providers' budget, and also the 4.9 Mbytes capacity is not enough at all for all prescriptions.

#### 3.3.1.2 Doctors' Desires and Conflict with Other Stakeholders

There exist some conflicts between doctors' needs and the desires of other stakeholders. Doctors are seeking an integrated e-prescription portal where they can easily log in, enter the patient's ID code, and retrieve and review the patient's entire health record before issuing any e-prescriptions. However, Iranian Basic Insurance companies have developed their portals primarily to prevent misuse for their own benefit, often showing less regard for the benefits of other stakeholders. As a result, there is no collaboration among these insurance companies to provide an integrated system.

On the other hand, the Ministry of Health in Iran cannot enforce such integration as its role is primarily supervisory. Thus, a conflict arises between the desires of doctors and Iranian Basic Insurance companies. Given that the Iranian Basic Insurance companies, as the primary developers of most e-Health applications in Iran, hold more power (as discussed in detail in section 2.4), their desires tend to take precedence and doctors' needs are neglected.

#### 3.3.1.3 Relations between Unique Challenges in Iran and Doctors' Need

In the figure 3.3, we tried to find meaningful relation among unique challenges in Iran and doctors' need. In other words, we tried to rooting for the doctors' needs based on unique challenges in Iran that we discussed in details in chapter context analysis in section 2.2.

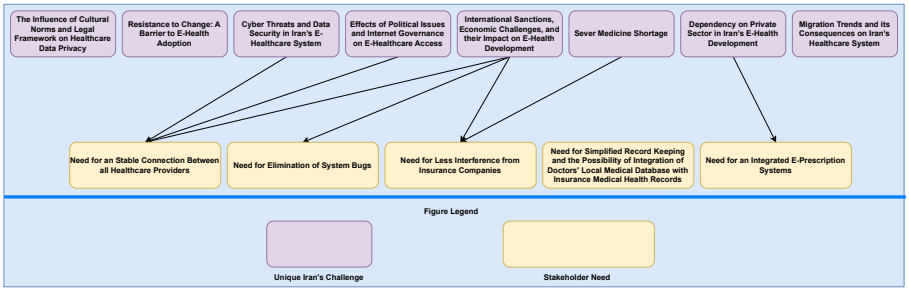



**Figure 3.3:** Doctors' Needs Rooting Based on the Unique Challenges

As we can see in the figure 3.3, there exists some potential relation between doctors' desires and unique challenges in Iran. We describe each of these in below.

- **Need for an integrated E-Prescription Systems:** The lack of an integrated system for e-prescriptions and patients' health records may stem from Iran's e-Health development depending on private sectors, particularly basic Iranian insurance, rather than governmental or public stakeholders. As mentioned, private sectors prioritize their benefits and often prefer competition over collaboration to gain more customers. Consequently, the lack of an integrated system for managing patients' health records and e-prescriptions, allowing doctors to log in to one system and perform their tasks, is likely rooted in the country's strong dependence on the private sector for e-Health developments.

- **Elimination of System Bugs:** The need to address various system bugs is common in any system and any country, and is not specific to developing countries like Iran. However, Iran faces unique circumstances that can exacerbate IT-related problems. As we discussed in section 2.2, the United States has imposed economic and technological sanctions on Iran since 1979. These sanctions have forced Iran to rely solely on domestic technologies, including software and hardware. These technology-related sanctions have had a negative impact on the development of any e-service, including e-Health. According to "Tejaratnews", a Persian news agency in Iran, "The sanctions of technology giants have paralyzed Iran's software industry! Some

sanctioned services also have other substitutes; but they lack the quality of the main service providers and cannot provide services as they should."[1]. The inability to use products developed by high-tech companies, combined with restrictions on knowledge sharing between Iran and other countries in terms of technology, has led to software of relatively lower quality. These conditions have forced the country into technological isolation.

- **Simplified Record Keeping and the Possibility of Integration of Doctors' Local Medical Database with Insurance Medical Health Records:** There is no significant connection between the need for Simplified Record Keeping and the Possibility of Integration of Doctors' Local Medical Databases with Insurance Medical Health Records, and the unique challenges in Iran that we discussed in section 2.2.

- **Less Interference from Insurance Companies:** The strictness of insurance companies regarding payments for expensive medication is common worldwide; they generally aim to ensure that payments are only for necessary services and medicines. However, Iran has been grappling with medical shortages due to various reasons such as global economic sanctions. This country cannot collaborate with international pharmaceutical companies to import the required quantity of medicine, leading to severe shortages, as discussed in detail in section 2.2. These shortages result in escalating prices for medicines. Insurance companies, which developed almost all e-Health services in this country, leverage their access to data to verify whether doctors prescribe rare and expensive medicines out of necessity. If, based on their review of patients' medical health data, they deduce that the prescribed medicine is not necessary, they request an explanation from the doctors. Thus, we can see a significant connection between sanctions, medical shortages, and doctors' desire for less interference from insurance companies.

- **Need for an Stable Connection Between all Healthcare Providers** As we discussed in section 3.3.1, the lack of a stable internet connection brings about various challenges for doctors. The lack of stable internet, or indeed any reliable local connection, between users engaged in e-Health services in Iran can be attributed to several unique issues within the country. These include Cyber Threats and Data Security in Iran's e-Health System, Political Issues impacting Internet Governance

[1]The specialized media of Tejaratnews is a private media with a large number of viewers, and it aims to reflect the voice of the popular economy in Iran, without political orientation and far from a biased view. Link to news:https://tejaratnews.com

and e-Health Access, as well as International Sanctions. Various cyber attacks, as discussed in section 2.2.2, have led to unstable internet connections. For instance, in section 2.2.2, we highlighted an incident where "In the continuation of the attack on Iran's government websites, the website of the Forensic Medicine Organization was also hacked in September 2022". Another connection between the unique challenges in this country and the need for stable connections for doctors could be the Political Issues and Internet Governance impacting e-Health Access. Policymakers can disconnect all citizens from the internet whenever they want, thereby preventing doctors from prescribing online, pharmacists from preparing prescriptions, and patients from accessing their prescriptions and collecting their medicine. These shutdowns do not happen hardly ever, and we can say people suffer from this issue several times a month as we can see a short timeline of these shutdowns in figure 2.3. The final significant correlation between these challenges and the doctors' needs might be the lack of any international Internet Service Providers (ISPs) in Iran due to sanctions (We discussed this subject in detail in section 2.2.4). Domestic ISPs might face technical challenges and are also subject to control by policymakers, having to shut down the internet whenever they receive a mandate from policymakers.

### 3.3.2 Pharmacist' Needs and Objectives

Pharmacists play a vital role in the broader landscape of e-Health advancement. As detailed in Mendelow's Power-Interest Grid in section 2.4, pharmacists exhibit a high level of power and interest. Unlike doctors, who not only review patients' health records but also prescribe online, pharmacists primarily check the patients' prescriptions received from doctors. To understand the workflows of pharmacists in greater detail, we employed Business Process Model and Notation (BPMN) diagrams following semi-structured interviews with two pharmacists - Dr. Mohammad Ali Abu Torabi and another who preferred to remain anonymous. The BPMN diagram and the verification of this workflow, aided by patients who used e-prescriptions and received their medicines from pharmacies, are discussed in chapter 5.

Similar to doctors, pharmacists have certain needs and desires within the e-Health system. This section of the research aims to understand these needs in detail. It is worth noting that pharmacists' needs are relatively fewer compared to doctors, given their primary role of retrieving the patient's prescription, and then preparing and dispensing the medications. Similar to doctors, pharmacists experienced problems related to Internet disconnection according to Dr. Mohammad Ali Abu Torabi (Pharmacist). He mentioned, "*A brief disruption in internet connectivity lasting five minutes has resulted in a notable degree of discomfort among patients. The recent internet outages have caused significant inconvenience and disruption to work productivity.*". In addition to collecting data through semi-structured interviews, we utilized common news agencies in Iran such as Tejaratnews [1] and Isna.

*"Referring to the definite impact of the Internet on prescriptions and insurance services, the vice president of the Health Insurance Organization told Isna: 'In the last month, due to the special conditions of the country and the slowness of the Internet, there was a 20% drop in the number of electronic prescriptions, but services are still provided in paper form. And electronics continues.'"*

*"According to Tejarat News, in recent days, extensive internet disruptions have caused serious problems for electronic prescribing and insurance systems. As the relevant authorities report a 20% drop in online prescribing. An issue that has caused crowding in pharmacies and doctor's offices, especially during the days of increased outbreaks of seasonal diseases.*

[1] The specialized media of Tejaratnews is a private media with a large number of viewers, and it aims to reflect the voice of the popular economy in Iran, without political orientation and far from a biased view. Link to news:https://tejaratnews.com

*Now it seems that prescriptions and insurances are the latest victims of the internet outage in Iran."*

The anonymous pharmacist also mentioned that the insurance systems are inadequate, and using them is just a waste of time. He said, "*I just have a username and password that should be shared by the technician. How can I trust my technician to retrieve the patients' data?*" He stated, "*Pharmacists have to log in and enter patients' ID numbers in different insurance portals, and we have some patients who do not even know which insurance they are using!*" In this pharmacist point of view, there is a need for improvement and integration of the systems. He also expressed concern that patients' privacy can be easily compromised, as they have to share their usernames and passwords with their technicians.

During the interview with Dr. Mohammad Ali Abu Torabi, a pharmacist, we asked about medicine shortages and how pharmacists can effectively help patients find rare medicines without them having to visit numerous pharmacies. He stated, *"The reality is that we pharmacists are supposed to enter our inventory into the system, but only about five out of 100 pharmacies actually do so. It has not caught on much in Iran. I've seen debates where the Ministry of Home Affairs, for instance, says we sell vaccines and insulin, and some argue we must register the milk powders on the TTAK website and register their barcodes. In the event of a drug shortage, more monitoring is required.".*

Below, we present an itemized version of pharmacists' desires and expectations, which resulted from the first step of our needs assessment:

- **Need for Better Authentication:** According to the semi-structured interviews, technicians, rather than pharmacists, are responsible for preparing patients' medicine in pharmacy. The pharmacists' roles is primarily to verify the medicine dose and conduct the final check before dispensing the medicines to patients. However, the insurance portals only provide a username and password for the pharmacist to retrieve the prescribed medicines, leading a situation that pharmacists might have to share these authentication details with their employees. There is a need for improved authentication methods so that every person working with the system can have their own credentials. The interviewed anonymous pharmacist expressed stress concerning sharing his/her authentication with employees. Thus, we see a need for changes in the authentication procedures, since the privacy of pharmacists and patients may be compromised. It should be noted that the process of receiving medicines through e-prescriptions can be observed in the drawn BPMN provided in section 5.0.4, and

without this IT-based tool it was difficult to understand that most of work in pharmacies are conducted by the technicians.

- **Need for an integrated E-Prescription Systems:** Similar to doctors, pharmacists use various insurance websites to retrieve the patients' required medicines. The websites used are the same as those doctors use for retrieving patients' medical history and prescribing online. However, these portals direct the pharmacist to a new page based on their authentication details. Authentication on various websites seems time-consuming and annoying for the pharmacist. It is worth mentioning that these portals use timers and automatically log out pharmacists after a certain period of inactivity for security reasons. Due to this mechanism, pharmacists and technicians have to log in to the systems for each patient, a process that they find time-consuming and irritating. Thus, there is a need for an integrated e-prescription system to save pharmacists' time.

- **Need for a Stable Connection:** Similar to doctors, pharmacists and their employees face various issues with the internet, generally related to network connection. As one of our interviewees mentioned, both patients and pharmacists suffer from an unstable internet connection. The situation worsens whenever policymakers decide to shut down the internet due to internal political problems, as we discussed in section 2.2. Patients then have to either wait for network connection restoration or make an appointment with their doctor and ask for a paper-based prescription. This solution is challenging, as doctors visit various patients every day and cannot easily recall what they prescribed previously to fill a handwritten prescription. Thus, there is a clear need for stable connectivity, either through the Internet or an Intranet, for pharmacists.

- **Need for database of rare drugs and insurance sites** Iran has faced severe shortages in medicine over the past decade. The Ministry of Health prepared a website and a global database, namely TTAC, which allows pharmacists to search where parents can find rare medicine. This database is supposed to be kept updated by the pharmacists, and other pharmacists use this data to refer the patient to where they can collect the rare and unavailable medicines. Since the e-prescription system is developed by insurance companies, these databases must be updated manually by the pharmacist after each customer transaction. The reason is that when a pharmacist sells a medicine based on an e-prescription, this transaction is not logged in

the pharmacy's local database and the global database shared among all pharmacies, and pharmacists have to register this transaction manually. As Dr. Mohammad Ali Abu Torabi mentioned, only a small proportion of pharmacists keep this database updated. Before the implementation of e-prescriptions, using this global database among all pharmacies was useful, since prescriptions were handwritten and all pharmacies used TTAC as storage systems. After the implementation of e-prescriptions, a gap was experienced and pharmacists faced challenges. Therefore, there is a need for a system to conveniently inform patients about the pharmacy where they can find rare medicines.

#### 3.3.2.1 Pharmacists' Awareness regarding their needs

The pharmacists, who took part in our interviews in an iterative process, were aware of the current challenges being experienced in e-Health services in Iran. However, sometimes they do not have enough resources, including time, money, and decision-making power, to fulfill some of their needs. For example, they are aware of internet connection problems, but they are not decision-makers who can prevent an internet shutdown in Iran. At the same time, they understand that maintaining a global database shared among all country's pharmacies could significantly help patients collect their medicines, but they do not have enough time to manually update the database. Stakeholders like these can be categorized into the third group of 'awareness', as discussed in section 3.1.

#### 3.3.2.2 Pharmacists' Desires and Conflict with Other Stakeholders

Between the wants of other stakeholders and the needs of pharmacists, there are some conflicts. When preparing medications, pharmacists want an integrated e-prescription portal that makes it simple to log in, enter the patient's ID code, and access the list of prescribed medications. Iranian Basic Insurance companies, on the other hand, have developed their portals to prevent misuse for their benefit. Due to this lack of cooperation between different insurance, there is no integrated system offered by these insurance companies. The Iranian Ministry of Health, on the other hand, is primarily a supervisory organization and cannot compel such integration. Thus, there is a conflict between Iranian Basic Insurance companies' and pharmacists' needs.

#### 3.3.2.3 Relations between Unique Challenges in Iran and Pharmacists' Need

Figure 3.4 shows a correlation between the unique barriers present in Iran and the pharmacists' needs. In other words, we aimed to advocate for the requirements of pharmacists, taking into account the distinct obstacles present in Iran, which were analyzed in the section 2.2.

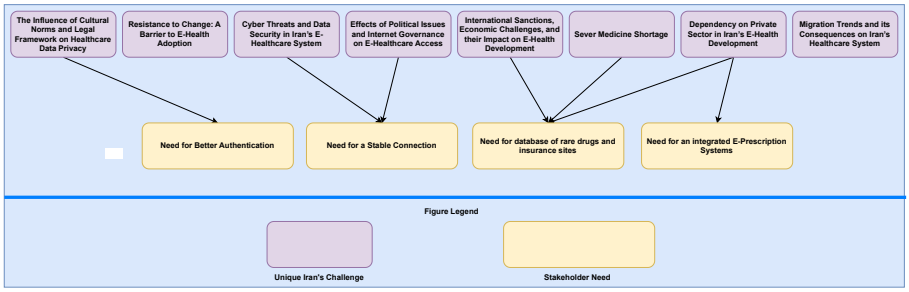



**Figure 3.4:** Pharmacists' Needs Rooting Based on the Unique Challenges

As shown in figure 3.4, some potential correlation exists between doctors' desires and unique challenges in Iran. We describe each of these below.

- **Need for Better Authentication:** Pharmacy technicians who work in pharmacies are usually responsible for reading patients' prescribed medicines from the system, then preparing and attaching the consumption manual before pharmacist confirmation. They do not have separate usernames and passwords with distinct access levels, so pharmacists are often compelled to share their own authentication information with them. There is an urgent need identified by pharmacists to provide distinct authentication information. The lack of distinct authentication information with different access levels for different employees might stem from cultural norms and the legal framework surrounding healthcare data privacy. Unlike some other countries that prioritize patient privacy and emphasize information confidentiality, people in Iran appear to be less concerned about their data privacy, as discussed in detail in section 2.2.1. A pharmacy is owned just by the pharmacist and other stuff, including techniques, might work there for a period of time. According to both pharmacist interviews, technicians are responsible to prepare the required medicines.

- **Need for an integrated E-Prescription Systems:** Similar to doctors, pharmacists also prefer to save time when retrieving patients' prescriptions from various insurance websites. The existence of multiple portals for retrieving patients' prescriptions might stem from the fact that insurance companies, most of which are

in the private sector, developed these e-prescription portals independently, without collaborating to deliver an integrated service. The problem of a lack of an integrated portal can become more severe under the condition that a patient changes his/her insurance agency and at the same time, he/she is not aware of the used agency for the prescription. Therefore, we can observe a significant relationship between the lack of integrated e-Health services and a country's dependence on various private service providers, such as basic Iranian insurances.

- **Need for a Stable Connection:** Pharmacists have encountered difficulties whenever the government decides to shut down the country's internet without prior notice. A strong correlation exists between the need for a stable connection and unique circumstances in Iran, including cyber threats and data security in Iran's e-Health system, and the effects of political issues and internet governance on e-Health access. We can conclude that pharmacists' need for a stable connection, which is rooted in the mentioned reasons, is relatively unique to Iran.

- **Need for database of rare drugs and insurance sites:** Before the implementation of e-Health in Iran by private insurance companies, a global database existed among all of the country's pharmacies. This database was used to refer patients to a location where they could access rare and unavailable medicine, provided it was not available in their local pharmacy. Pharmacies updated this database on a daily basis automatically, as it also served as their warehouse management program. However, recent e-Health developments have shifted the focus of pharmacists away from this database, known as TTAC. TTAC is not connected to basic insurance websites, and pharmacists find it difficult and time-consuming to manually update this separate database. As a result, patients often have to visit multiple pharmacies to find rare medicines. Under these circumstances, there is a need for integration between basic Iranian insurance and the Ministry of Healthcare database (TTAC). We have determined that this need is rooted in the country's dependence on private sectors (such as insurance companies), international sanctions which result in medicine shortages, and local reasons leading to medical shortages.

### 3.3.3 Patients' Needs and Objectives

Within the broader scope of e-Health advancement, patients can be seen as stakeholders who have the least power and interest in using e-Health services. These stakeholders engage indirectly in Iran's e-Health ecosystem. Recent developments have contributed to not only tangible benefits such as fewer prescription errors but also intangible benefits such as more precise diagnoses by doctors with the aid of patients' health records. Patients have certain desires and expectations from e-Health services. However, since they are not directly engaged in these services, and they do not have even access to their own medical health records directly, including prescribed medicines, doctors' notes, and medical test results, their needs usually are not directly related to current e-Health developments. Like other stakeholders, patients also suffer greatly from internet shutdowns and medicine shortages. If patients cannot find rare medicines, they are compelled to visit several pharmacies. In the past, it was much easier for patients to access these rare medicines with the help of the TTAC database. However, based on conducted interviews, this database is now updating by only a small percentage of pharmacists and has lost much of its usefulness following the implementation of insurance e-Health portals.

- **Need for facilitating finding rare medicine:** According to Dr. Mohammad Ali Abu Torabi (Pharmacist) "*We pharmacists are supposed to enter our inventory into the system, but only about five out of 100 pharmacies actually do so. It has not caught on much in Iran.*". This outdated TTAC database is not useful at all, and there is a need for a solution which facilitates the patients' accessing into rare medicines. Thus we can see a need for an informing system which help patients find their required medicines, and prevent visiting several pharmacies.

#### 3.3.3.1 Patients' Awareness regarding their needs

Patients interviewed were aware of the current issues in Iran's healthcare system, and sought solutions that might assist them. However, their influence is insufficient, and they lack the power to effect change. We can categorize the patients as a group of stakeholders who are aware and seeking improvement, but they do not have enough power, as shown in Figure 3.2.

#### 3.3.3.2 Patients' Desires and Conflict with Other Stakeholders

There is not any meaningful conflict between patients' desires and expectations from e-Health and the desires of other stakeholders.

#### 3.3.3.3 Relations between Unique Challenges in Iran and Patients' Need

Figure 3.5 shows a correlation between the unique barriers present in Iran and the patients' needs. As can be seen in this diagram, sanctions and severe medicine shortages have forced Iranian patients to search for their prescribed medications across various pharmacies. There is not any feature for referring patients to rare medicines in the services developed by insurance, which leads to confusion for patients. We can see a weak correlation between the dependency on private sectors' developed e-Health implementation and the lack of an easy way to find rare medicine.

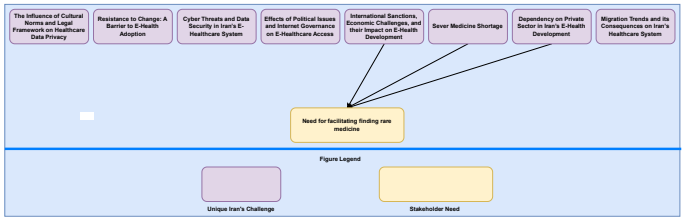



**Figure 3.5:** Pharmacists' Needs Rooting Based on the Unique Challenges

# 4

# Evaluation of Existing IT Infrastructure

In the previous chapter of our study, we sought to understand the key stakeholders' requirements and desires through an intuitive process. We conducted semi-structured interviews to listen their stories and understand their desires. In this phase of our methodology, we aim to understand and evaluate the IT infrastructure in Iran to address the Research Question 1 which is *"How can we analyze a complex context such as healthcare in Iran to understand the state, challenges, and limitations of e-Health in the country?"*. The result of this phase of the study is necessary to provide a practical treatment design, which is expected to do in the next step of our research.

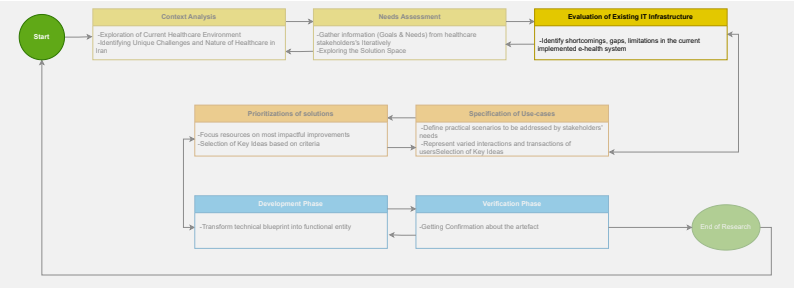



**Figure 4.1:** Research Methodology Diagram (Third Step of the Methodology)

## 4.1 Internet Access

In the year 2023, the level of internet penetration in Iran was recorded at 78.6 percent as also shown in figure 4.2, indicating a total of 69.83 million individuals utilizing the internet.[1]. This shows a rise from 70.0 percent internet penetration in 2021 when 59.16 million people used the internet.[2]. In 2023, approximately three-quarters of Iran's population lived in urban areas, while one-quarter lived in rural areas. According to a 2020 report, internet connectivity was available in 100% of cities and 78% of villages, indicating that internet access is widely available in both urban and rural areas.[3]. According to worlddata.info [4] and Ookla[5], with an average download speed of 11.97 Mbit/second for fixed-network broadband internet, Iran ranks 145th in an international comparison. However, the upload rate of only 2.3 Mbit/second was significantly lower (175th place). In mobile internet, Iran comes 62nd with a download speed of 35.98 Mbit/second. The upload speed of around 11 Mbit was only enough for 79th place. A modern 5G network does not yet exist in Iran. The penetration rate of 4G, mobile communications with at least LTE speed, was recently 81 percent. In other words, 16.71 million people in the country had to make do with a maximum Internet speed of the universal mobile telecommunications system standard.

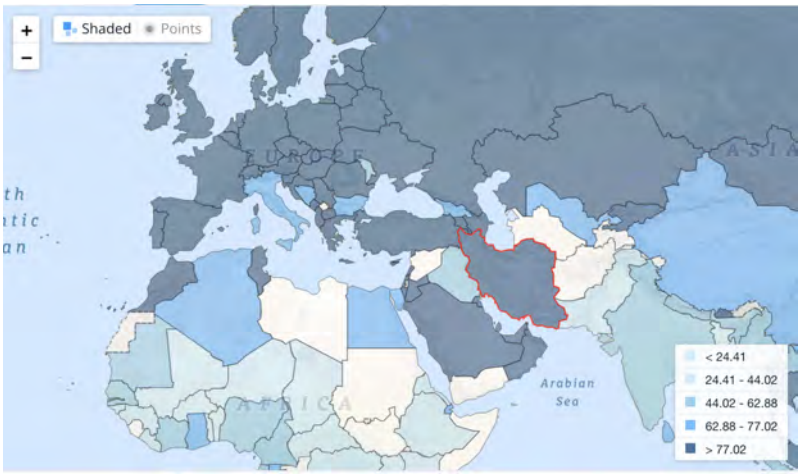



**Figure 4.2:** Individuals using the Internet (% of population)

[1]Source of Internet Penetration in Iran in 2023
[2]Source of Internet Penetration in Iran 2023
[3]Freedom House - Iran: Freedom on the Net 2020 Country Report
[4]Our World in Data is a scientific online publication that focuses on large global problems such as poverty, disease, hunger, climate change, war, existential risks, and inequality. www.worlddata.info/asia/iran
[5]Speedtest.net, also known as Speedtest by Ookla, is a web service that provides free analysis of Internet access performance metrics. Link: www.speedtest.net/global-index

## 4.2 Internet Stability

Although 78.6 percent of Iranians have access to the internet, this connection is not at all stable. Policymakers often shut down the internet entirely in the country due to various reasons that we discussed in section 2.2. This interruption hampers numerous e-commerce services, including e-Health services. As we discussed in the needs assessment phase, almost all key stakeholders have suffered from these interruptions, which began in 2019. Over the years, Iranian authorities have followed a pattern of blocking social media apps, numerous websites and even resorting to shutting networks entirely, implementing overall pervasive levels of Internet control. We also presented a timeline showing a recent one-month period of internet shutdown in this country, as shown in Figure 2.3. This Internet shutdowns is not a new problem in this country, and it has happened since 2019 frequently.

### 4.2.1 The Used Method for Internet Shutdowns in Iran

Iranian authorities have followed a pattern of blocking social media apps, numerous websites, and even shutting down networks entirely over the years, implementing overall pervasive levels of Internet control based on Open Observatory of Network Interference (OONI)[1].

- **Blocking of HTTP/3 and QUIC traffic:** A large number of protocols are in charge of lower-level functionality (like the transmission of raw data), and they all cooperate to support the HyperText Transfer Protocol (HTTP), the fundamental component of the World Wide Web that enables users to request data from servers. This protocol has been updated most recently to HTTP/3. Users lose access to the performance and security benefits these protocols offer when they are blocked. In the event that they are blocked, users might become more susceptible to targeted filtering and security problems. The Open Observatory of Network Interference (OONI) cited Iranian policymakers' alleged blocking of these auxiliary protocols as an example of a tactic they had previously employed to bring the Internet to a halt in September 2022.

- **IPv6 disruption:** IPv6 is the most recent version of the Internet Protocol, the low-level protocol that allows computers to communicate using unique "IP addresses." It supersedes the older IPv4. Traffic using the IPv6 networking protocol dropped substantially in some of shutdown in Iran, suggesting the protocol might have been

[1]Link to report by OONI

blocked according to OONI's report. However, it is still being determined what substances this would have for most users.

- **Increased blocking of encrypted DNS:** DNS (Domain Name Service) allows Internet devices to alter names to IP addresses. DNS works just like a phone book, But instead of calls, it delivers the physical location of the website address. When someone opens a website, Internet browsers use the DNS registered on the domain and find the server to show its information. Usually, when the government shuts down the internet, it closes it to normal users, which is why "DNS" is still active. The user must design his own "DNS" system to bypass the filter at this level. This can bypass the default DNS provided by the ISP. Encrypted DNS has been introduced in recent years to improve users' Internet traffic privacy and security, making it more difficult for governments to monitor and block access to Internet services. Encrypted DNS exchanges DNS data over secure protocols such as TLS and HTTPS, concealing the names of requested websites and services from authorities and preventing them from interfering with DNS results. Many Iranian ISPs, however, have increased their efforts to block secure domain name resolution servers (DNS over HTTPS, or DoH) through various technical means. DoH makes it more difficult for network administrators to identify and block access by encrypting the names of the websites a user visits. As a result, blocking DoH can make circumvention more difficult.

## 4.3 Sanctions' impact on Iran's IT Infrastructure

According to the IT-related sanctions imposed on Iran, many companies and financial firms are not allowed to collaborate with Iran. These sanctions create a situation where IT specialists in the Ministry of Health and insurance companies are not allowed to use updated software. The lack of possibility for receiving updated versions of software can mean that there is a high chance of security problems in outdated software. According to Donya-e-Eqtesad[1], a major part of the price of software subscriptions in the country consists of the support provided by the software company during implementation, a benefit from which Iran is deprived. Based on interviews conducted by an associate professor at Sharif University by Donya-e-Eqtesad, the sanctions have forced policymakers to use hacked versions of some software required by the country. As a result, the correctness of performance and the security of organizational systems have been threatened.

[1]Donya-e-Eqtesad is an Iranian daily newspaper and book publisher. Report Link

As a result of international sanctions, domestically-developed software for mobile platforms are not allowed on international stores such as the Apple App Store and Google Play. Iranian-developed applications are instead published on domestic app stores like Cafe Bazaar[1].

As a result of investigation of IT infrastructure in Iran, we figured out that the below table of the software companies hesitate to provide services to Iranian residents.

| **Companies that Boycotted Iran Digitally** | | |
|---|---|---|
| Google Hangouts Plugin | Adobe | Adobe Air |
| Adobe Flash | Adobe Reader | Airbnb |
| AMD | American foundation for the blind | Android Developer |
| ArcGIS Online | ArcGIS Online Developer | Authy |
| Azure (Microsoft) | BeMyEyes | BitBucket |
| Bitdefender | Black Berry Developer | Blackblaze (Cloud Storage and Backup) |
| Buddy Build (Continuous Integration, Development & user Feedback) | cgsociety | Change dot org |
| Chrome Experiments | CJ Affiliate Marketing | CoreOS |
| Coursera | cyme | Dell EMC |
| Developer Android | Digital Ocean | Docker |
| Enom (Domain Registrar) | Envato Market | Envato Market |
| Firebase | Firefox Send | Firefox Send |
| Flurry Analytics | Freelancer | Gitlab |
| Go (Programming Language) | Go Docs | GoDaddy |
| Google - Adsense | Google - Adwords | Google - Cloud |
| Google - Code | Google - Developers | Google - Fiber |
| Google - GSuite | Google - Summer of Code | Google Analytics |
| Google App Engine | Google DNS | Google Doodles |
| Google Maps | Google Play - Amazon Kindle | Google Play - Clock by Google |
| Google Play - Duolingo | Google Play - Facebook | Google Play - FB Messenger |
| Google Play - Instagram | Google Play - Last.fm | Google Play - Line |
| Google Play - Linkedin | Google Play - Mapquest | Google Play - Periscope |
| "Google Play - SOMA free video call and chat" | Google Play - Trello | Google Play - Twitter |
| Google Play - Wickr | GrabCad | GraphicRiver |
| Hot examples | Internet health Report | Internet.bs (Domain Registrar) |
| InVision | Java | jetbrains students |
| Khan Academy | Matworks | Mbed (IoT Device Development) |
| Mcafee | Microsoft Store | MongoDb University |
| Mysql | Name (Domain Registrar) | Namecheap |
| "Norton Antivirus and Norton SSL" | NVIDIA | Open SRS (Domain, email, SSL, etc) |
| Optimizely | Oracle | Pandora (Music Streaming Service) |
| PeoplePerHour | PhotoDune | Playster |
| Polymer Project | Real Player | Reseller Hosting |
| Resello (Domain Registrar) | Samsung Developer | Snapchat |
| SoftLayer | Solar Winds - IT Management | SpiceWorks |
| Spotify | Stackoverflow | Stripe |
| Sun | Symantec & Norton | Team Viewer |
| TeamViewer | Texas Instruments | Themeforest |
| Twilio | Ubisoft Store | Unity Game engine and analytics |
| VideoHive | vimeo | VirtualBox |
| VirusTotal | Visa | VISA Developer |
| VMWare | VMWare | vmware (main website, forums) |
| Wix | Wordpress (.com) | Xbox Live |
| xyz top level domain registration | Google - YourPrimer | ZXing Decoder Online |

**Table 4.1:** Companies that Boycotted Iran Digitally

[1] https://cafebazaar.ir/app

## 4.4 Opportunities and Advancements

Approximately 78 percent of villages in Iran have access to high-speed Internet. However, we should consider that this percentage does not necessarily indicate the proportion of villagers who use the Internet. Various factors, such as electronic literacy levels, financial means to purchase devices like computers and mobile phones, and their interest in using the Internet can affect the percentage of people who actually use it. The existence of Internet access can be seen as an opportunity for e-Health service development in this country. This high percentage of Internet accessibility in Iran's villages suggests that people there can easily employ telemedicine services, such as online consultations and online medicine ordering.

# 5

# Business Process Model and Notation (BPMN)

In this chapter, we utilized Business Process Model and Notation (BPMN) to understand the underlying structures of healthcare and e-Health services in Iran. We conducted interviews with healthcare providers and users to gather the necessary information for constructing the BPMN diagrams. The data collection process presented challenges due to contradictory statements, making it difficult to determine the most accurate representation. To tackle this problem, we conducted interviews with 9 stakeholders to ensure there is no contradiction between stakeholders' stories and experiences while working with e-Health services. As the processes vary between private and public healthcare sectors, including participants from both sectors in our interviews was crucial. After conceptualizing the interview findings using a Business Process Modeling and Notation (BPMN) method, we requested feedback to verify their accuracy. Given the complexity of BPMN diagrams for those without prior knowledge, we created animations to simplify the understanding process for model verification. This approach proved beneficial as it allowed us to refine and enhance the quality and precision of our diagrams in an iterative process. In this chapter, we will describe each BPMN diagram in detail, and the result of this chapter can be used to address the Research Question 1, which is *How can we analyze a complex context such as healthcare in Iran to understand the state, challenges, and limitations of e-Health in the country?*.

### 5.0.1 Making Appointment

In Iran, to visit a doctor, whether a general practitioner or specialist, patients are not required to be registered with any specific medical center. Patients can freely choose their preferred doctor and make an appointment. In contrast, some countries like the Netherlands use a referral system known as a 'Gatekeeping' based healthcare system. In this system, every person is registered with a specific healthcare service, and a general practitioner may refer the patient to a specialist, but only if it is truly necessary. Gatekeeping by primary care general practitioners is a critical component of robust primary care and is associated with cost containment. Therefore, building an efficient gatekeeping system is a significant concern for policymakers and healthcare professionals. However, many countries (e.g., France and Belgium in Europe, and the Republic of Korea and Japan in Asia) do not use a gatekeeping system where patients need referrals from GPs to access advanced care (20). A Gatekeeping system in Iran might be needed to overcome some specific difficulties, such as long waiting lists for specialists, resulting from healthcare provider shortages and some cultural preferences. Based on our interviews, people in Iran prefer to visit a specialist first, owing to the belief that treatment outcomes are better than visiting a general practitioner, and there is no significant difference in the cost of visits. This preference leads to long waiting lists for specialists and denies access to advanced health services for those indeed in need of visiting a specialist.

In the BPMN diagram, we can see that patients just need to call any private or public hospital to visit a general practitioner or specialist. The operator is then responsible for evaluating the severity of the health problem to schedule an urgent or routine appointment for the patient. Unfortunately, no official criteria exist to determine the severity of a health problem, and it becomes a negotiation between the patient and operator to determine the urgency of the appointment. Both private and public hospitals can send an ambulance for patients who cannot visit the hospital. The service is almost free at public hospitals, while private hospitals charge significantly. Hospital employees use either a paper-based or digital calendar to update doctors' schedules. This is not a formal procedure, and each hospital manager adopts a specific approach in this matter. As we mentioned in our methodology it was important for us to deliver precise BPMN diagrams, and used animations to verify our output in an iterative process. A screen shot of made animation can be seen in figure 5.2 for making appointment and BPMN model of this process is shown in figure 5.1.

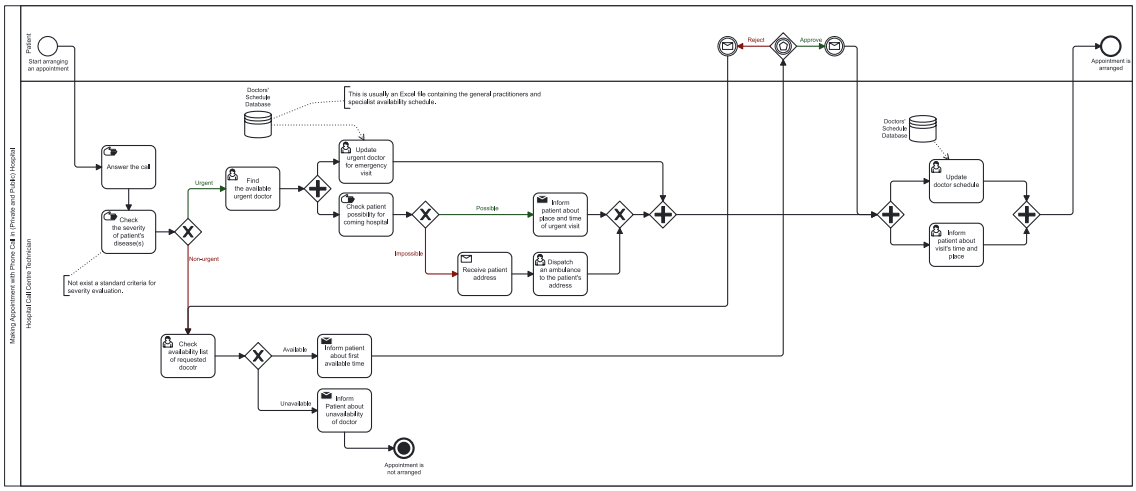



**Figure 5.1:** BPMN Model of Making Appointment Process

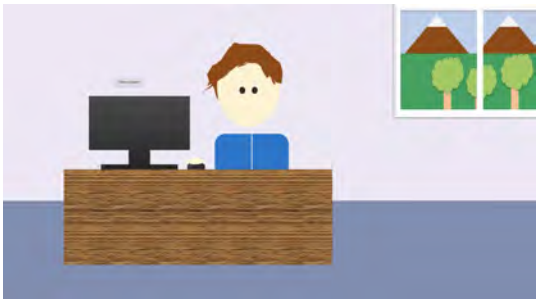


**Figure 5.2:** Animation of Making Appointment

### 5.0.2 Order Medicines in Online Pharmacy

In Iran, people can order necessary medicines through online pharmacies. Traditional pharmacies usually do not operate their websites but utilize popular platforms such as SnappDoctor and DrSaina to provide services. Most online pharmacies, such as Darokade [1], are only allowed to sell over-the-counter medicines. However, SnappDoctor[2] and DrSaina [3], two trusted and reputable startups in the private sector, are permitted to sell both prescribed and over-the-counter medicines. The rise of online pharmacies has brought several benefits to consumers and the healthcare system. Firstly, it provides consumers with convenience and accessibility. People can order medicines from the comfort of their homes,

[1] https://www.darukade.com/
[2] https://snapp.doctor/
[3] https://www.drsaina.com/

which is particularly beneficial for the elderly, disabled, or those living in remote areas. It also offers a discreet way of purchasing medicines for sensitive or personal health conditions. Furthermore, online pharmacies often have a more comprehensive range of products than physical pharmacies due to fewer space restrictions. This means consumers can access a broader selection of medicines and health products. They can also compare prices more easily across different online pharmacies, potentially leading to cost savings. It is worth noting that these platforms gained more visibility during the beginning of the COVID-19 pandemic. The reason for this popularity was that many physical pharmacies refused to provide services during this period, and Iran experienced a very challenging time. These startups made a concerted effort to maintain service provision in these conditions. Online pharmacies offer services almost in the national scale in collaboration with the Iran National Post. Additionally, they can provide faster service to certain cities with their specialized delivery services. In these ways, online pharmacies have helped revolutionize healthcare accessibility in Iran, providing vital services during times of need and improving the overall experience for many patients. To gather information and create the BPMN diagrams, we selected SnappDoctor as a case study. Furthermore, we ordered some prescribed medicines better to understand the customer journey during the medication ordering process. To validate our findings, we used animations that were sent to a selection of users, aiming to confirm the accuracy of the processes as we understood them. Based on this, we adjusted the BPMN diagram to produce an accurate representation.

#### 5.0.2.1 Order Over-counter Medicines

Ordering over-the-counter medicines in Iran does not require strict authorization in online pharmacies, and any individual can easily order the required medications. There are no restrictions, even for age-limited over-the-counter medicines, and registration on websites is based solely on a mobile number rather than any other personal information such as age or name.

Patients residing in large cities like Tehran can order and receive their purchases within four hours using the specialized delivery systems provided by these online pharmacies. However, for people living in smaller cities or remote areas, the national post service is the default delivery method. This service takes around a week for the ordered medicines to be collected.

Moreover, there are service points in a few cities, including Tehran, Isfahan, and Mashhad, which allow customers to collect their orders faster. Since none of the insurance

companies, including the basic Iranian insurance and supplementary insurance, cover over-the-counter medicines, this ordering process does not involve insurance companies at all. To verify the process of ordering over-counter medicines in an online pharmacy, animation again employed and we got feedback from users to be sure that we deliver precise BPMN diagrams. Figure 5.4 shows an instance of these animations for ordering over-counter medicines in online pharmacy and figure 5.3 shows the BPMN model of this process.

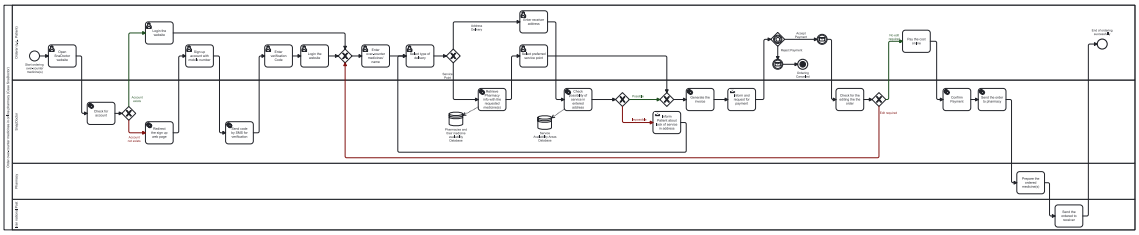


**Figure 5.3:** BPMN Model of Ordering the Over-counter Medicines in Online Pharmacy (Case SnappDoctor)

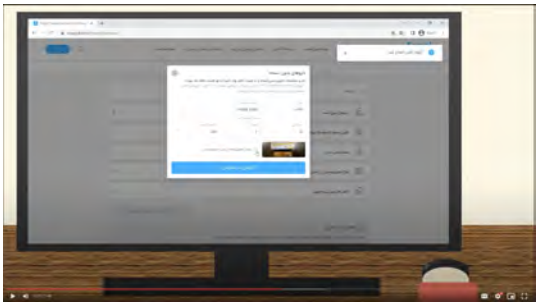


**Figure 5.4:** Animation of the Ordering Over-counter Medicines in Online Pharmacy (Case SnappDoctor)

#### 5.0.2.2 Order Prescribed Medicines

Patients who want to order prescribed medicines can use online pharmacies, either with a paper-based prescription or an e-prescription. To understand how this process works, we employed a BPMN diagram and used animations for verification by other users. For the paper-based prescription, the ordering process is more straightforward than for an e-prescription. The patient must scan the prescription and upload the certified version onto the SnappDoctor pharmacy website. An administrator at SnappDoctor then digitizes the paper-based prescription. This manual task might take up to 48 hours, according to our interviews with users. It is worth noting that doctors are required to include the patient's

national ID code even on paper-based prescriptions. SnappDoctor uses this ID to verify the user who submitted the prescription, matching it with the national number on the prescription. For this, SnappDoctor sends a verification code to the user's mobile number to ensure that the person who submitted the prescription is indeed the owner. Thanks to SnappDoctor's collaboration with Basic Iranian Insurances, they can confirm that the prescription genuinely belongs to the person who submitted the paper-based prescription. Some patients might prefer not to use insurance for various reasons, such as expired insurance or illegal residency in Iran. For these patients, doctors write the prescription on letterhead, sign it, and do not mention the national ID. In such cases, SnappDoctor does not provide service. For e-prescriptions, patients verified by their National ID and matching phone number must enter their national code. As part of the collaboration between SnappDoctor and Basic Insurance, SnappDoctor retrieves the patient's medicine list and asks the patient to select the necessary medicines. For patients who want to use Basic Iranian Insurances, SnappDoctor calculates the insurance and patient's share of payment and, after payment, provides a receipt that can be used by the patient to claim from supplementary insurance. For over-the-counter medicines, there are service points where medicines can be collected as a delivery option. In terms of prescribed medicines, these service points are pharmacies collaborating with SnappDoctor. In other words, traditional pharmacies are responsible for preparing the medicines and then sending them either to the patient's address or to other pharmacies near the patient. SnappDoctor collaborates with traditional (offline) pharmacies to avoid dispensing incorrect doses or wrong medicines, placing this responsibility on offline pharmacies. According to our research, only SnappDoctor and DrSaina are permitted to sell prescribed medicines, while various other online pharmacies sell over-the-counter medicines such as vitamins and pain killers. To verify the procedure of ordering medicines with hand-written and electronic prescription, we used animations and ask patients who had experience to give us feedback. Two screenshot of these animations can be seen in figures 5.6 and BPMN model can be find in figure 5.5.

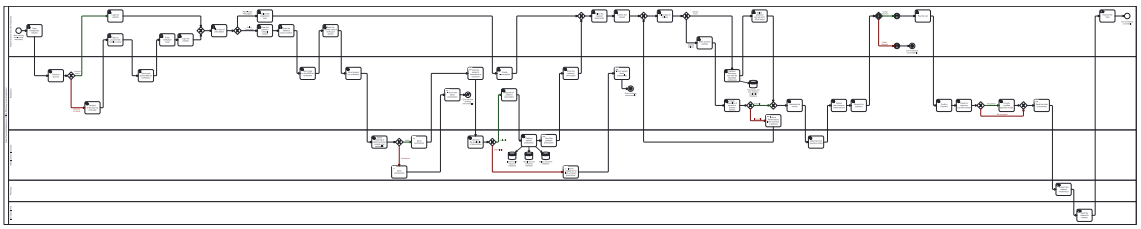
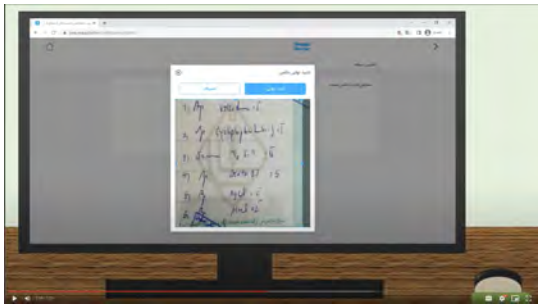
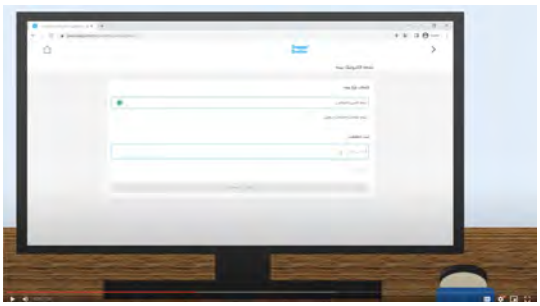


**Figure 5.5:** BPMN Model of the Ordering Prescribed Medicines in online Pharmacy



**(a)** Ordering Hand-written Prescription in Online Pharmacy



**(b)** Ordering Electronic Prescription in Online Pharmacy

**Figure 5.6:** Animation of the Ordering Medicines in Online Pharmacy

### 5.0.3 Prescription Process

The advent of e-prescription approximately three years ago marks a significant leap forward in Iran's e-Health sector. The importance of e-prescription stems from the fact that it facilitates a systematic recording of all prescribed medicines, test results, and medical imaging data as part of a patient's medical history. This well-structured history optimizes disease follow-up and consequently enhances treatment quality.

An interviewee, dr. Nima allahyari (Neurosurgeon), shared an anecdote illustrating this benefit: "In the past, I was not aware of the medicines I had previously prescribed to a patient. After a treatment period, I unintentionally prescribed the same medication again, despite an alternative being required. Consequently, my patient experienced severe illness." As this story reveals, an e-prescription system can be instrumental in preventing such scenarios, leading to a more accurate diagnosis and overall improved patient care.

This service, spearheaded by Iranian essential insurance companies like Social Security Insurance, Iranian Health Insurance, and Iran Military Insurance, has revolutionized the medical prescription process. It allows doctors to prescribe online medicines, medical tests, and imaging tests. In contrast, pharmacists and medical test service providers can conveniently access these prescriptions to provide the necessary services to patients.

While each insurance company developed a distinct system, there are more similarities than differences in their fundamental structures. The observed differences revolve around naming conventions for medical tests and medicines and additional features like the ability to generate medical certificates online. Social Security Insurance was at the forefront of this digital revolution, being the first to create an online portal for maintaining patients' medical records and prescriptions. Other Iranian essential insurance companies soon followed

quickly.

Based on user experiences and our interviews, the Social Security Insurance portal outperforms the others regarding user-friendliness and feature-richness.

In this section, we delve deeper into the e-prescription procedure, exploring its details through the lens of the associated BPMN diagram. To validate this BPMN, we referenced the user instructions of these insurance portals rather than animations. This method gave us an accurate understanding of these portals' operations and functionalities.

The first step in the prescription process involves doctors, whether general practitioners or specialists, determining if a certified prescription is required. If the doctor merely intends to prescribe over-the-counter medicine, they write the name of the medicine on a letterhead paper for the patient. However, the process becomes more complex when prescribing medicines that necessitate a certified prescription. The doctor begins by inquiring if the patient wishes to utilize their insurance. If the patient opts not to use their insurance for any personal reason, such as expired insurance, the doctor fills out a letterhead for the necessary medication and certifies it with a signature. Next, the doctor gauges the patient's preference for a paper-based or online prescription. The persistence of this practice could be attributed to the fact that several basic Iranian insurances has only recently adopted the online prescription system, and maintaining an option for paper prescriptions has become habitual. A crucial factor contributing to the continued use of paper prescriptions is that adopting e-prescriptions is not mandatory. According to our interviews, it is expected that e-prescriptions will become obligatory by the end of two following Iranian year (approximately the year 2025) , pending significant infrastructure improvements. Concerning patient privacy, we sought to understand if patients were reluctant to upload their information onto the online system. We asked most of the doctors we interviewed to gain insights: "Have you had a patient request not to include their information in the online system due to privacy concerns?" The majority responded negatively. This finding suggests that patients have minimal reservations about sharing their information, implying that privacy concerns are negligible. This attitude might be rooted in cultural behaviors, where trust in the healthcare system and professionals outweighs potential privacy issues. In the next step, doctors need to be sure the patient who requested the medication is the same as the insured patient. If patients prefer to use the paper-based prescription, they must bring the insurers' booklet, as shown in figure 2.8. The first page of these insurance booklets features the patient's picture, enabling the doctor to verify the patient's identity easily. If the patient opts for an online prescription, the insurance website displays the

patient's picture for verification. Verification is a necessary step in paper-based prescriptions due to instances of misuse. For instance, a patient might use his brother's insurance booklet when his insurance has expired, making authentication without a picture nearly impossible.

In online prescriptions, if a doctor notices a discrepancy between the patient's picture and the image in the system, the doctor will double-check. They will halt the prescription if they confirm that the patient is attempting to misuse someone else's insurance service.

Once the patient's identity is confirmed, the doctor prescribes the required medications, including medicines, medical tests, and medical imaging tests. For medical imaging tests, the doctor must explain the initial diagnosis to the individual who will conduct the medical imaging test. This explanation is also submitted through the insurance portal.

After the prescription process, whether paper-based or electronic, the doctor inquires if the patient has any supplementary insurance. If the patient does have supplementary insurance, the doctor will issue a certified prescription as a letter of certification that can be used for insurance claims. This rigorous process ensures the validity of the prescription and safeguards against misuse of the system, thereby maintaining the integrity of the healthcare services. The BPMN model of the e-Prescription can be find the figure 5.7.

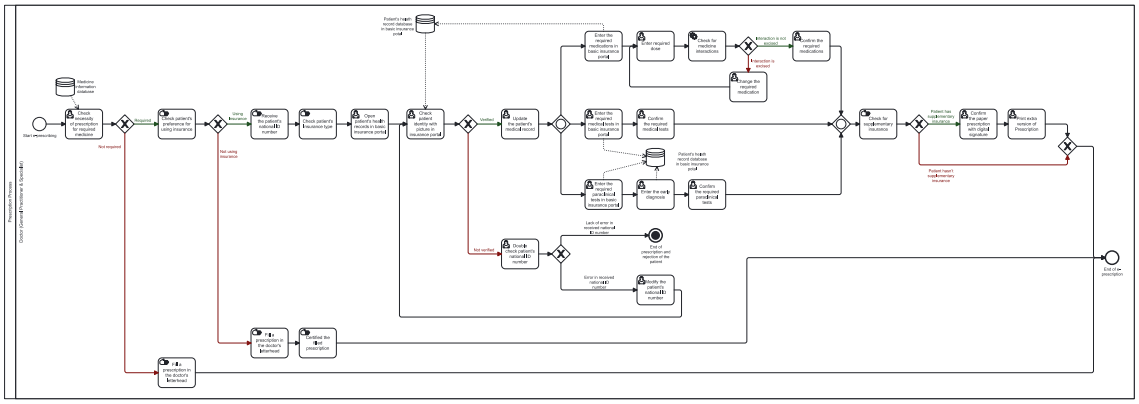


**Figure 5.7:** BPMN Model of the e-Prescription Process

#### 5.0.3.1 Prescribing Medical Diagnostic Tests

The e-prescription of medical diagnostic tests, such as blood tests and imaging tests, is an important component of Iran's e-Health system. This functionality simplifies and optimizes the healthcare process, enabling doctors to add new records to patients' medical histories and making it easier for them to prescribe tests and access the results.

Despite these advantages, it is essential to note that, according to the interviews we conducted, there are security issues in these systems that could potentially enable hackers to manipulate data. These challenges need to be continually addressed to maintain the integrity and confidentiality of patient information.

However, the system does offer significant benefits that outweigh these challenges. Doctors can prescribe the required medical tests through basic insurance websites, after which medical labs using these systems can transmit the test results directly to the doctors. This not only reduces administrative burden but also accelerates the process of result delivery.

Specific medical imaging tests require doctors to write a separate letter presenting their initial diagnosis to the professional who will conduct the imaging test. This procedure has been made simpler with the advent of the e-Health system, making it more straightforward for doctors.

Another advantage is the increased accessibility this system offers. Doctors from any location in the country can now access patients' health records, eliminating the need for patients to carry their test results with them. However, if a patient requests it, labs can still provide printed results.

Public Medical Diagnostic Test centers are usually located inside public hospitals in each city, and patients who use basic Iranian insurance can use these medical test centers either free of charge or for some tests at a very affordable price. However, these centers often have long waiting times due to factors like affordability.

Regardless of insurance status, every individual can use public medical test centers, though the services are free or discounted only for those with basic insurance coverage. People without basic insurance, like illegal migrants, must pay for these services out of pocket. Conversely, private medical labs, particularly in larger cities, offer premium services at significantly higher prices compared to their public counterparts. These private labs are strategically located in various parts of the cities to cater to different demographics and offer extended hours, making them easily accessible for patients seeking immediate attention. Despite the higher prices, the comprehensive range of services, the speed at which they are delivered, and the enhanced customer experience often justify the cost for many patients.

The process starts when a doctor prescribes medical tests for a patient. In the first step, the doctor, whether a GP or specialist, checks whether the patient wants to use insurance services or not. If the patient prefers not to use insurance for any reason, the doctor prescribes the medical test(s) on medical letterhead and then certifies the prescription with their seal.

Due to the technological sanctions imposed by the United States, conducting some medical tests is impossible in all medical labs, and just a few medical labs in big cities can conduct all medical tests. In such cases, some patients may need to visit several medical labs to find a center that can conduct the required test.

After conducting the tests, the medical lab generates the test results based on the prescription type. For paper-based prescriptions, the medical lab prints the result, while for e-prescriptions, the lab uploads the result on the insurance portal for the doctor to view. Patients then revisit the doctor, who checks for the test results either paper-based or online.

A significant difference between private and public medical labs is the payment structure post the conduction of the tests. Public labs calculate the basic insurance share, and the patient only has to pay a minimal amount as their share, or it may even be free. On the other hand, basic insurances cover only a tiny proportion of medical tests in private centers, and patients or their supplementary insurance must pay the remaining amount.

However, patients with supplementary insurance can either pay and then claim from their insurance, or their supplementary insurance can pay instead of them directly, which some supplementary insurances refer to as prepaid payment services. The BPMN model of the prescribing medical diagnostic tests in public and private medical labs are shown in figures 5.8 and 5.9 respectively.

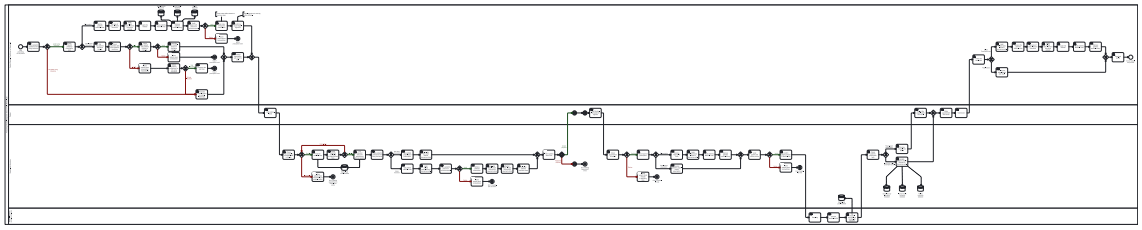


**Figure 5.8:** BPMN Model of the Prescribing Medical Diagnostic Tests in Public Medical Lab

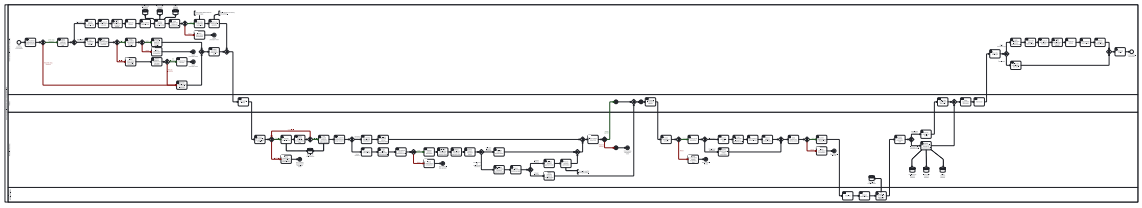


**Figure 5.9:** BPMN Model of the Prescribing Medical Diagnostic Tests in Private Medical Lab

### 5.0.4 Receiving a digital prescription from the pharmacy

The procedure of obtaining prescription medication from a pharmacy varies, influenced by different factors, including the type of medicine, the patient's insurance preferences, and the prescription's format. This process can notably differ for patients from rural regions who often present hand-written prescriptions.

The pharmacy technician must initially ascertain whether the patient intends to utilize their insurance coverage. Certain patients may opt out of insurance for various reasons, such as expired coverage or unauthorized immigration status. For these individuals, services are only available at physical pharmacies, with online platforms like SnappDoctor refraining from assisting.

After confirming the patient's insurance choice, the pharmacy technician evaluates the need for a prescription based on the required medication. If the medication demands a prescription, the technician requests one, such as a doctor's certified letterhead, an insurance booklet belonging to the patient, or an electronic prescription available on insurance portals.

Patients with supplementary insurance can either obtain a payment receipt for subsequent claims from their supplementary insurance or request the pharmacy to bill their supplementary insurance directly. Notably, direct payment options are only provided by a limited number of supplementary insurance providers, like SOS insurance - reputable supplementary insurance in Iran.

In the case of e-prescriptions, the pharmacy technician retrieves patient information from basic Iranian insurance websites by entering the patient's national number. Before this, the technician must identify the patient's basic Iranian insurance provider and log in to the appropriate insurance website. Each patient might subscribe to different insurance websites. Upon logging in, the technician is responsible for verifying that the patient in the pharmacy aligns with the national ID entered in the system by comparing the patient's photograph with the picture on the insured person's profile.

However, given the recent launch of the some insurance portals, various technical glitches have emerged, and some patients' profiles might lack photographs, as per an interview conducted in October 2022. Following successful patient confirmation, the pharmacy technician probes the local pharmacy database for the required medications.

Regrettably, the economic turmoil caused by international sanctions has led to significant shortages of various medicines. In response, policymakers, including the Ministry of Healthcare, has developed an online database, namely TTAC, that can be used to seek

rare medicines at other pharmacies and guides patients toward these locations. Despite these measures, several problems persist with updating this database, as indicated by our interviews. The database often contains outdated and erroneous information, as pharmacists neglect to update it regularly. Nevertheless, certain pharmacies collaborate to order the necessary medicines for their patients.

When the required medicine is in stock, the pharmacist prepares it, accompanying it with a consumption manual detailing the doctor-prescribed amount. This prescription may either be hand-written or electronic. Prioritizing patient safety, the pharmacist scrutinizes the prescribed dosage before dispensing the medications to the patients, ensuring adherence to the correct dosage instructions. The BPMN model of the process is shown in figure 5.10.

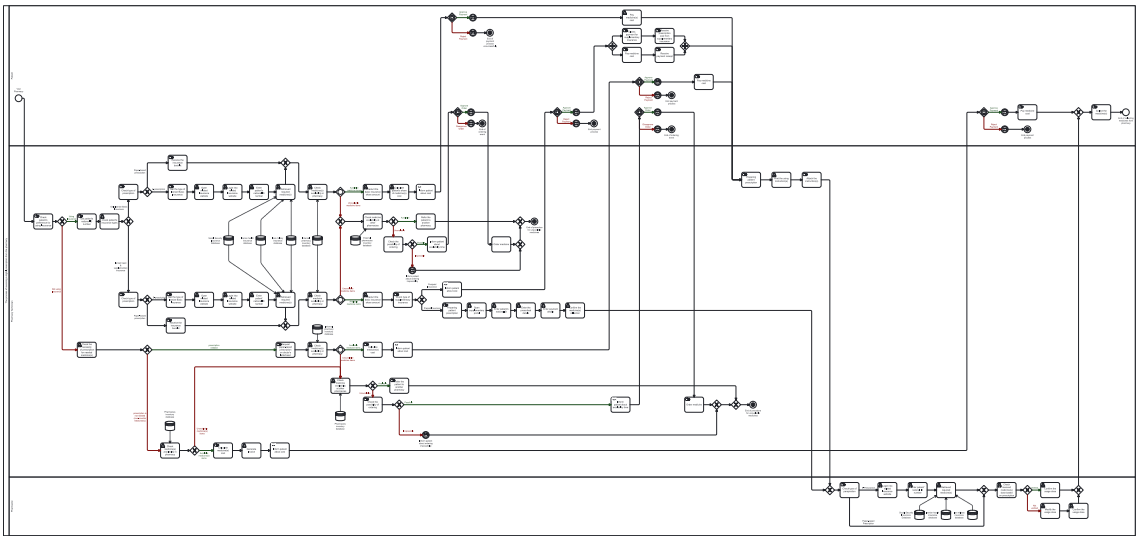


**Figure 5.10:** BPMN Model of the Process of Collecting a Digital Prescription

### 5.0.5 Visiting Health Home Centers

While e-Health increasingly prevalent in Iran's urbanized regions, its developments are not as widespread in the country's rural areas. Typically, every few villages host a health home - a facility to streamline healthcare services. A general practitioner manages these health homes and features an on-site pharmacy with essential medicines. Patients are referred from these health homes to public hospitals in the nearest cities when necessary. Given that the rural population predominantly utilizes Iranian health insurance, consultations with GPs at these health homes are free. Patients only incur costs for their share of the medication. Based on one of our interviews, prescriptions in rural areas are primarily handwritten, with other interviewees needing help to provide insight into prescription procedures. Some health homes have ambulances, which is only universal across some facilities. During the initial visit to a health home, a patient is required to make an appointment. The doctor's secretary verifies the patient's identity and checks the expiration date of the patient's insurance booklet. Following the appointment setup, the patient visits the health home for a consultation with the GP. If necessary, the GP diagnoses the condition and refers the patient to a hospital or specialist. The GP also writes the required medication in the patient's insurance booklet. If the health home's local pharmacy has the necessary medicine, the patient can collect it directly. If the required medication is unavailable, the patient is referred to another pharmacy in the nearest city. The lack of e-Health implementations in rural regions underscores the need for more inclusive healthcare digitalization strategies. To bridge this gap, it is essential to invest in infrastructure development, such as improving internet connectivity, providing digital literacy training to healthcare providers, and ensuring the accessibility of e-Health services for all population segments. The BPMN model of the process is shown in figure 5.11.

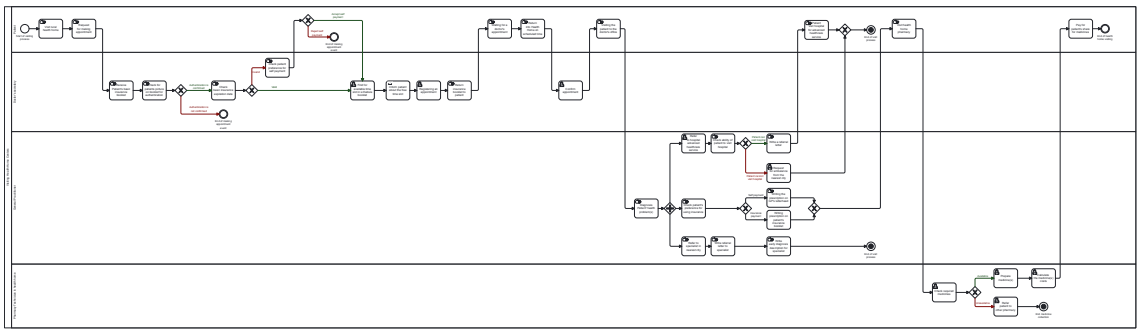


**Figure 5.11:** BPMN Model of the Visiting Health Home Centers Procedure

# 6

# Use Cases Specification and Prioritisation

In this phase of the project, we propose appropriate user-centered e-Health solutions within a Iran's complex context that has been developed to meet the key stakeholders' requirements. This chapter is written to address Research Question 2, which is *"How can we identify the needs and requirements of stakeholders in the health sector to design appropriate user-centered e-Health solutions within a complex context, such as Iranian healthcare system?"*. It is important to note that addressing some of the use case seniors to improve e-Health system in Iran extends beyond the scope of our project, and we are explicitly considering IT-based treatments for the specific use cases not entire e-Health system in Iran. We have established criteria to prioritize solutions when we have more than one solution. As this study (4) discussed, there are many possible alternative paths between the problem space and the solution space. A solution space can be explored given a specific problem. Because the outcome of innovation cannot be predicted in advance, its trajectory also cannot be predicted.

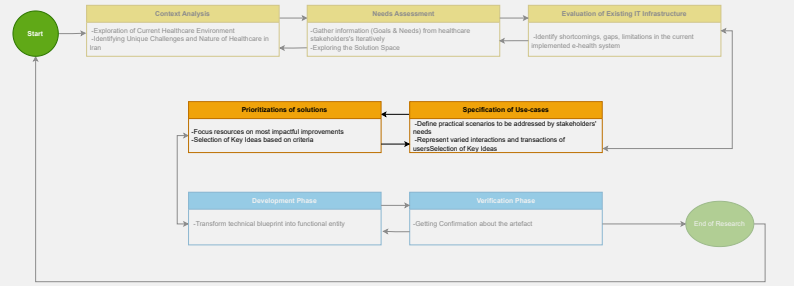



**Figure 6.1:** Usecase and Proposed Solutions (Fourth step of methodology)

## 6.1 Correlations Between Stakeholder Requirements and Unique Challenges in Iran

In table 6.1, we provide a table to capture all key stakeholders' requirements shown at one glance. In this table, one can find the key stakeholders' requirements and potential correlation between their requirements and unique circumstances in Iran as an isolated developing country in middle east. In this table we determine the common requirements between key stakeholders with same colour.

| **Doctors (GP and Specialist)** | | |
|---|---|---|
| **Doctors' Requirements ID** | **Requirements** | **Unique Challenges** |
| *Doctor_N_1* | Need for an integrated e-Prescription Systems | Dependency on Private Sector in Iran's e-Health Development |
| *Doctor_N_2* | Elimination of System Bugs | International Sanctions, Economic Challenges, and their Impact on e-Health Development |
| *Doctor_N_3* | Simplified Record Keeping and the Possibility of Integration of Doctors' Local Medical Database with Insurance Medical Health Records | - |
| *Doctor_N_4* | Less Interference from Insurance Companies | International Sanctions, Economic Challenges, and their Impact on e-Health Development e-Health Development |
| | | Sever Medicine Shortage |
| *Doctor_N_5* | Need for an Stable Connection | Cyber Threats and Data Security in Iran's e-Health System |
| | | Effects of Political Issues and Internet Governance on e-Health Access |
| | | International Sanctions, Economic Challenges, and their Impact on e-Health Development e-Health Development |
| **Pharmacists** | | |
| **Pharmacists' Requirements ID** | **Requirements** | Unique Challenges |
| *Pharmacist_N_1* | Need for Better Authentication | The Influence of Cultural Norms and Legal Framework on Healthcare Data Privacy |
| *Pharmacist_N_2* | Need for an integrated e-Prescription Systems | Dependency on Private Sector in Iran's e-Health Development |
| *Pharmacist_N_3* | Need for a Stable Connection | Cyber Threats and Data Security in Iran's e-Health System |
| | | Effects of Political Issues and Internet Governance on e-Health Access |
| *Pharmacist_N_4* | Need for database of rare drugs and insurance sites | International Sanctions, Economic Challenges, and their Impact on e-Health Development |
| | | Sever Medicine Shortage |
| | | Dependency on Private Sector in Iran's e-Health Development |
| **Patients** | | |
| **Patients' Requirements ID** | **Requirements** | Unique Challenges |
| *Patient_N_1* | Need for facilitating finding rare medicine | International Sanctions, Economic Challenges, and their Impact on e-Health Development |
| | | Sever Medicine Shortage |
| | | Dependency on Private Sector in Iran's e-Health Development |

**Table 6.1:** Key Stakeholders' Desires and probable Correlation between Requirements and Unique Circumstances in Iran

## 6.2 The Criteria for Solution Prioritization and Evaluation

After proposing the potential solutions, we need to find the most feasible ones based on a criteria list when we have more than one artifact for a need. This prioritization will be helpful to find the most suitable solution based on the different factors, such cultural factors, in a country. According to (4), the outcome of innovation cannot be predicted in advance. However, we can increase the success chance of ICT4D solution by selecting the most suitable project. For each criteria, we consider a scale low, middle and high.

- **Cost:** Analyze all project-related costs, such as development, maintenance, hardware, software licensing, training, and any necessary infrastructure changes.
- **Security:** Although Iranian culture norms are not particularly sensitive to security and privacy-related matters, we must consider this criterion as an important factor for solution prioritization. We must consider this factor for solution prioritization, since we are working with sensitive data like patients' medical records. However, it should be noted that security prioritization should not be so strict that it makes the use of our solution overly challenging and discourages users. We should pay attention into trade-off between security factors and ease of use.
- **Development Time:** Considering the estimated time for development and deployment of a project is an essential factor that can impact solution prioritization. Sometimes, the development of a project might take a lot of time, during which stakeholders may lose interest or no longer need the solution.
- **Stability:** The stability of the proposed solution is also crucial. It is unwise to develop a project that only works for a short period of time. We need to ensure a logical balance between the stability of a project's usefulness and the time and money spent on the project.
- **Ease of Use:** The proposed solution should be easy to use. A complex system may require comprehensive instruction and may encounter resistance from end users.
- **Technical Feasibility:** The proposed solution should be supported by the existing infrastructure, including hardware, software, and staff technical skills.
- **Legal and Regulatory Compliance:** Ensure that the solution adheres to all relevant local laws and regulations, such as data protection laws and industry-specific regulations.

## 6.3 Proposed Solutions for Need for an Integrated e-Prescription System

According to Table 6.1, we can see that both doctors and pharmacists have expressed a need for an integrated system for e-Health services, including e-Prescriptions, retrieving patients' medical records from insurance portals, and retrieving prescribed medicines. This need may be correlated with the country's firm reliance on the private sector, particularly insurance companies, which are pioneers in developing e-Health in Iran. If either public or governmental stakeholders had driven these recent e-Health developments, as we discussed in detail in section 2.3, there would have been a higher likelihood of a unified e-Health service being instigated. Under the current conditions, all the basic Iranian insurance companies compete with each other to promote their own systems rather than collaborating on an integrated system. We cannot definitively state that this lack of collaboration results in low-quality output, nor can we assert that collaboration is the only path to a better outcome for the system. However, competition between them could be an encouraging factor contributing to higher quality service. Nonetheless, the result of having a multitude of service providers offering the same service implies a low chance for integration. This issue can be particularly problematic for doctors wanting to access patients' medical health records when a patient changes their insurance, with part of the patient's data located in the former insurance system and the remainder in the new insurance system.

### 6.3.1 Use Case 1: Addressing the Need for an Integrated e-Prescription System

The first idea to address this need might be a third-party application, including either web or mobile applications, that facilitates access to various insurance portals in one place. With the help of this third-party portal, doctors can prescribe the required medicines in one location, and the application then transfers the data to the relevant insurance portal automatically. With the aid of this third-party application, doctors are not required to visit various e-Prescription portals. They can easily enter the patients' National codes, and the application will retrieve the patients' data automatically from all insurance portals. Simultaneously, pharmacists can enter the patient's national ID and view the medicines prescribed by doctors from the relevant insurance portals, rather than visiting multiple websites. As the project involves handling sensitive patient data, it needs to comply with all applicable laws and regulations, such as those related to data privacy and protection. To develop this solution technically, we can employ two distinct approaches, including the

third Party Application with the API and third Party Application with the web crawlers. These two approaches, namely application programming interfaces [1] (APIs) and web crawling are most common methods to data exchanges.

**Third Party Application with the API Approach:** The first approach is that each of these insurance companies provides a safe Application Programming Interface (API). In the next step, our third-party application uses these provided APIs to exchange data between our integrated system and insurance portals, as shown in figure 6.2. Regarding the APIs' benefits, we can say that APIs usually provide better security mechanisms than web crawling techniques to guarantee that only authorized users can access the data or services. The requester does not have to worry about being identified as a malicious actor and can expect assistance from the websites if the API fails unexpectedly. Also, the retrieved data by the APIs are mostly clean, and it is not required for complex data cleaning processing. However, we should consider that API technology should be provided by the insurance. If they do not support an API, this option does not work at all. Furthermore, using APIs is not free of charge.

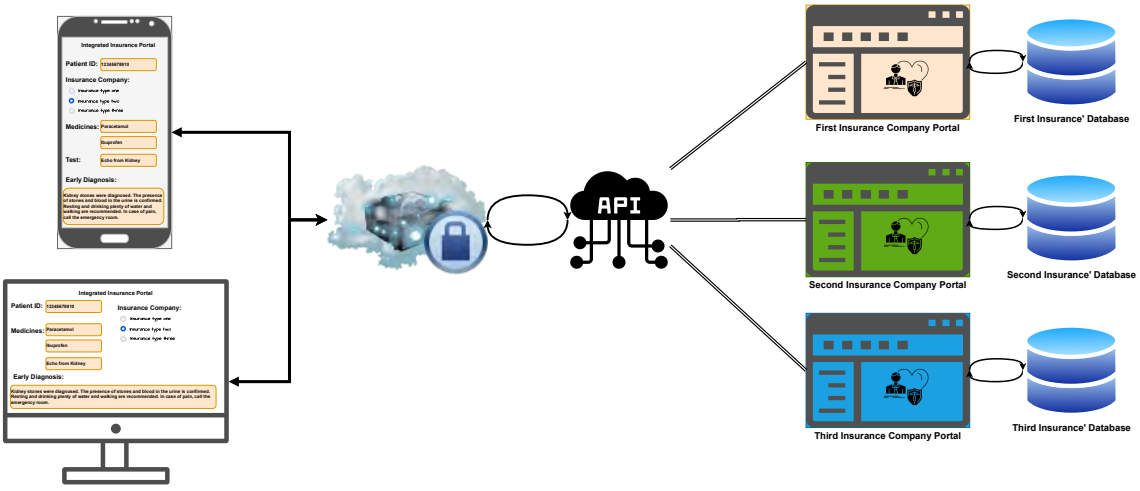



**Figure 6.2:** Integrated Insurance Portal with API

**Third Party Application with the Web Crawler Approach:** The second strategy employs web crawling techniques, which allow us to navigate the web using scripts and identify the HTML tags on each insurance portal rather than using an API (shown in

[1] API stands for application programming interface. API is a set of definitions and communication protocols that connects a computer to a person.

figure 6.3). These tags can be used to fill an e-Prescription or to enter patient data, such as the national ID code, in order to retrieve patients' health records. Pharmacists can also use this technique to retrieve prescribed medications. Web crawling does not need to be technically supported by the website. Regarding the stability of this approach, we can say the third-party application might stop working if the insurance portals modify their websites by adding or removing a feature. So we can conclude that this approach needs high maintenance efforts since our third-party applications must be updated regularly to be worked without problems. Web crawling technology is free of charge. Concerning safety, it is safe as the APIs since, in this method, we do not save data anywhere, and our script just acts as a machine-based actor that exchanges data between a third-party application and insurance portals rather than doctors and pharmacists. Thus it is safe as the regular situation in which a doctor or pharmacist enters or retrieves data manually. In other words, this approach allows us to turn a user task as shown in BPMN diagrams in chapter 5, which is entering data by doctors and pharmacists into a script task.

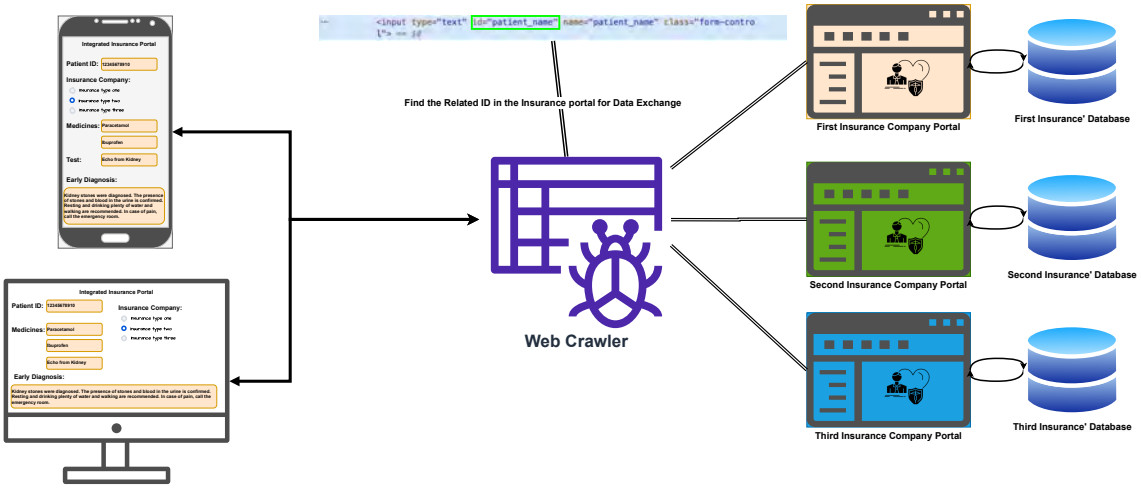



**Figure 6.3:** Third Party Application with the Web Crawler

#### 6.3.1.1 Evaluation of Use Case 1: Integrated e-Prescription System

Based on the introduced criteria in section 6.2, we can see that integrating the entire system with a third-party application might be too costly since it needs high-cost maintenance and expensive hardware to handle all requests from end user, such as pharmacist and doctors. In terms of security, we evaluate that third-party applications can be entirely

secure because insurance provides its APIs. However, the security of a third-party application with the help of web crawling can be a middle category, since there is high chance of data manipulation. Developing a third-party application with the insurance API can be straightforward technically. Also, we categorize developing this application in a low-time category with APIs. However, developing a third-party application with web crawling can take more time to figure out HTML tags, and we categorize it in middle-time development. Regarding the stability of the solution, we can say the developed app with the APIs is fully trusted and stable, and we categorize it in the highly stable category. However, stability for web crawling techniques is lower than developed applications with APIs, and it can be categorized in the middle stability category since insurance might update their websites and change their HTML tags. Using this artifact is easy for doctors and pharmacists, so we categorize high easy to use. Developing a third-party integrated application with APIs is not technically feasible since insurance does not have a tendency. In contrast, developing this application with web crawling is technically entirely feasible. This solution is fully legal, and there is no regulatory compliance to stop working on this solution.

### 6.3.2 Use case 2: Addressing the Need for an Integrated Login System (DargahRahyab)

The second use case for addressing the lack of an integrated insurance portal could involve adding a new layout to the current insurance portals without delivering medical data. In other words, we would provide a new portal where doctors and pharmacists enter their login details. From that point onwards, they would need to enter the patient's insurance type, and our new portal would redirect them to the relevant insurance websites. This strategy would save time for all key stakeholders and prevent the need for manually checking and logging into various websites. The sequence diagram based on this use case and blueprint can be seen in the figures 6.4 and 6.5, respectively. In software development, a blue print is a detailed design to shows software user interface. All of the doctors' and pharmacists' login details will be saved on their local devices after encryption with a private key based on their device's processor ID. Thus login details only will be kept and used on the doctor's and pharmacist's devices. This approach gives us the confidence that no one can misuse the patients' data. We can develop this idea with cross-platform framework like Flutter and develop output for IOS, Android, and desktop versions at the same time. This extra layout we should add can act as a shortcut that helps end-users use various insurance portals more straightforwardly with auto-logging systems. Also, we can add biometric authentication for mobile platforms to improve the application's security. According to the interviews, these

insurance portals log out the users automatically after some time, and doctors sometimes have to log in several times to use the portals for different purposes. This added layout facilitates the process and lets users use the system safer and faster. It is worth mentioning that we developed this use case technically, and named it DargahRahyab. We discussed the development of this use case in chapter 7.

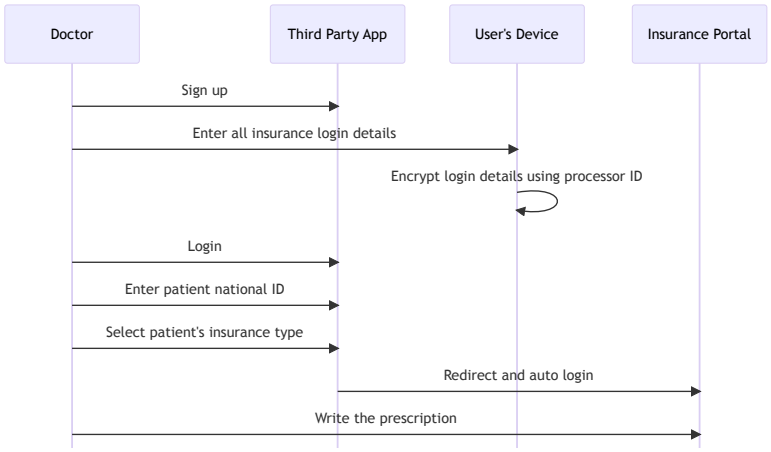



**Figure 6.4:** Sequence Diagram of e-Prescription

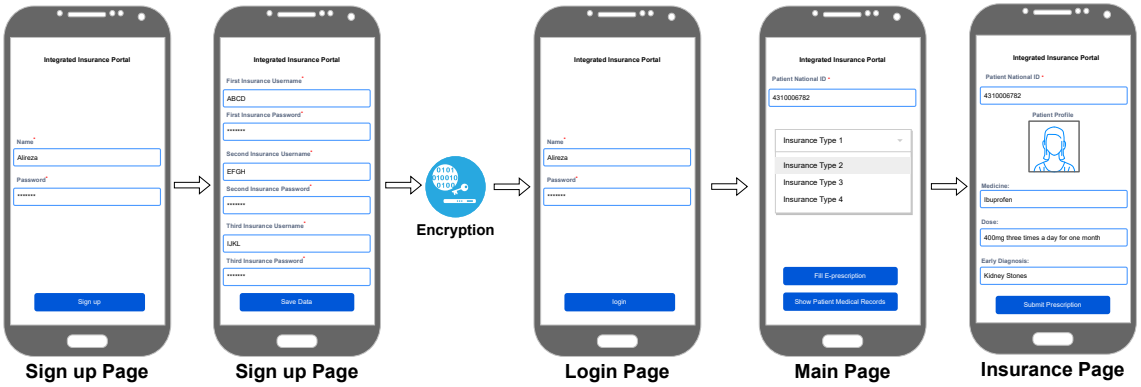



**Figure 6.5:** DargahRahyab (Blue Print)

#### 6.3.2.1 Evaluation of Use Case 2: Integrated Login System

Developing a new layout for the current e-Prescription systems dose not have significant costs and expensive maintenance and hardware, as we aim to enhance the login process and assist users in reaching their destination website more straightforward. In terms of

security, this solution is as safe as the current system, and it does not affect the existing system's security, as all login data is saved locally on the user's device and encrypted. Therefore, we can claim this solution could even improve the system's safety by adding an extra security layer, such as biometric authentication. Concerning development time, this solution does not require a significant time, as it does not need to replicate the entire insurance website, like use case 6.3.1. Instead, we merely add a new layout to the login step. Regarding the solution's stability, it is completely unaffected by any future updates from insurance companies. It is also highly user-friendly for both doctors and pharmacists, thus we categorize this solution as highly user-friendly. In terms of technical feasibility, the proposed solution is fully viable based on the current infrastructure. As we do not save or deliver patient data, this additional layout is entirely legal. We merely save the doctors' login info on their devices in encrypted form.

### 6.3.3 Prioritization of Use Case for the Need for an Integrated e-Prescription System

According to a conducted evaluation in subsections 6.3.1.1 and 6.3.2.1 based on criteria in section 6.2, we can conclude that the second use case, as discussed in 6.3.2 is more beneficial and can help doctors and pharmacists for having more straightforward e-perception system easier and with the lower cost. Moreover, the second use case can enhance the system's security by adding a new layout to the current system. Finally, we developed the second use case, namely DargahRahyab and discussed its developments and verification phase in chapter 7.

## 6.4 Proposed Solution for Need for Simplified Record Keeping and Less Interference from Insurance Companies

According to Table 6.1, it is evident that doctors require integration of their local database (patients' medical records) with the current insurance medical health records. As we discussed in Section 3.3.1, some doctors, particularly specialists, have maintained patients' medical records on their own prior to any e-Health implementations in this country. This was due to the fact that they might have patients requiring long-term treatments, making it necessary to record medical data for tracking treatment progress, medications used, and test results. With the development of e-Health, doctors sometimes have to check their locally recorded medical history (either in excel form or handwritten form) for former patients as well as the new history on the insurance portals.

Similarly, insurance companies ask doctors about prescribed rare, foreign, and expensive medicines on the condition that they are not aware of the previous medications prescribed for the patients. This lack of awareness might stem from the fact that the doctor only recently started using the e-Health services (as the use of e-Health services is not yet widespread) and insurance companies do not have updated information about used alternative domestic medicines.

Therefore, transferring patients' data from doctors' local history to the insurance companies can be beneficial for addressing need of the simplified record keeping and less interference from insurance companies. While manually transferring data from doctors' local databases to insurance companies is possible, it is a time-consuming process with a high probability of human error. Thus doctors looking for an authentic method and innovation. It is worth mentioning that every single patient should give permission to doctor to share their data on the Insurance websites.

### 6.4.1 Use case 1: Integration of Doctors' Local Database and Insurance Database for Comprehensive Patients' History Records

According to our interviews, specialists recorded patients' medical history in three distinct forms: (i) hand-written notes, (ii) unstructured digital note, and (iii) structured data. For the hand-written form, we first need to digitize the paper-based information. Generally, we could suggest Optical Character Recognition (OCR) techniques to convert the hand-written versions into a digital format. However, we noticed that Iranian doctors often write prescriptions in a combination of English and Persian languages. They typically write the names of medicines in English, while writing the dosage and other instructions

for medicine consumption in Persian, as shown in Figure 6.6. There currently is not any OCR model that can accurately differentiate between these two languages at the same time based on our investigation. Given the importance of patients' medical history, we cannot rely on this method to digitize hand-written medical histories. For the unstructured text, we can employ a model that identifies the necessary parts of the text and converts it into a structured dataset using a script. For the structured data, no extra action is required as they are already in a format ready to be uploaded onto insurance websites. As a result of employing this solution, we can combine the doctors' local database and insurance database for comprehensive patients' history records, and address the lack of integration of Doctors' Local Database and Insurance Database for Comprehensive Patients' History Records. To push the data into insurance portals, we can employ two distinct approaches. The first approach is to use any existing API from insurance portals. This approach allows us to parse the data and then send it to the insurance portals. However, no such APIs currently exist for this purpose. The second approach is to identify each input field HTML tag ID and then use web scripting techniques, like web crawling, to paste the structured data into insurance portals one by one. This approach does not require any preconditions, such as an API, from the insurance websites.

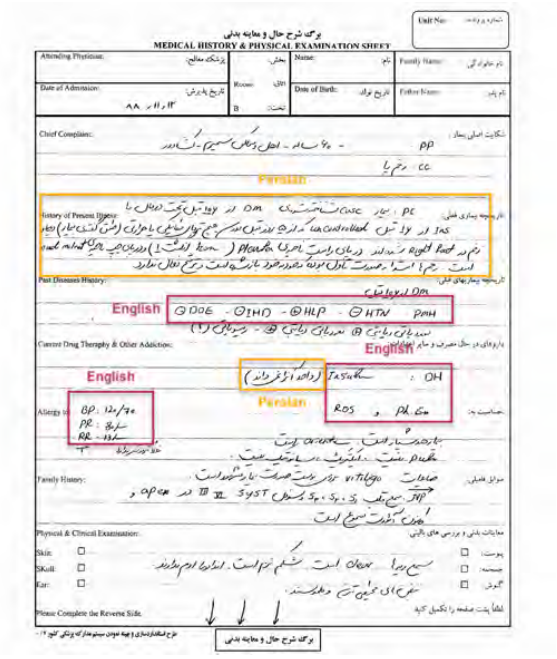



**Figure 6.6:** Hand-written Sample (English and Persian at one Prescription)

## 6.5 Proposed Solution for Need for an Stable Connection

Although a high proportion of Iranians have access to high-speed Internet, as indicated by our infrastructure analysis in Section 4.2, many Internet connectivity issues persist in the country, resulting in unstable access. This is a unique circumstance that we have discussed in detail in section 2.2.3. Based on our understanding from infrastructure analysis, Iranian policymakers have employed various strategies to shut down the Internet under different situations, including blocking of HTTP, IPv6 disruption, and increased blocking of encrypted DNS, as discussed in Section 4.2.1. All e-Health developments rely on the Internet rather than any local network such as an Intranet. However, due to security issues and cyber threats discussed in Section 2.2.2, Iranian policymakers have blocked access from outside the country to almost all local e-services, including e-Health services. Without a doubt, addressing this need might require solutions beyond the scope of our research and need more advanced solutions either from government entities or primary Iranian insurances. Nonetheless, we propose some solutions that can increase the chance of connectivity.

### 6.5.1 Use case 1: Need for Stable Connection

In the context of the first two methods employed for Internet shutdown, namely blocking of HTTP and IPv6 disruption, our key stakeholders could theoretically use a Virtual Private Network (VPN). A VPN conceals the user's actual public IP address and "tunnels" traffic between the user's device and the remote server, allowing Internet users to change their IP location. However, this method is not applicable since e-Health services like e-Prescription websites are only accessible with an Iranian IP address. Thus, there is no method to overcome Internet shutdown when policymakers employ HTTP blocking and IPv6 disruption methods. Nevertheless, as we discussed in Section 4.2.1, policymakers employed another method, namely blocking DNS. DNS associates various information with domain names assigned to each of the participating entities. Users can manually change their DNS to a public DNS like Google Public DNS to regain Internet access. This method is safe since all data is exchanged via the former routes. Since the IP address remains the same, users won't lose their access to internal websites that block access from outside the country. Even though this solution could technically work, there are legal and ethical implications to consider. Circumventing government restrictions, even if technically possible, could potentially lead to legal repercussions for the user. Thus we do not suggest to use these proposed technical solution at all, although they are working.

## 6.6 Proposed Solution for Need for Better Authentication

Based on interviews conducted with pharmacists, we learned that technicians are responsible for preparing medicines for patients, with pharmacists checking everything after preparation. This process is depicted in our BPMN diagram in Section 5.0.4. Pharmacists expressed concern about having to share their login information with their technicians, which could potentially impact patient privacy.

### 6.6.1 Use case 1: Need for Better Authentication

To address this issue, we could implement a new layout similar to what we discussed in Section 6.3.2. With this solution, all pharmacist information is saved locally within the software, and each technician can have their own login code without knowing the main login password. Moreover, we could limit access to insurance websites while logging all activities to ensure that patients' data is fully safe and under the constant monitoring of pharmacists. The blue print of this solution is shown in figure 6.7. In software parlance, a blueprint is the high-level plan or outline depending on which the end product, that is the software, is going to build.

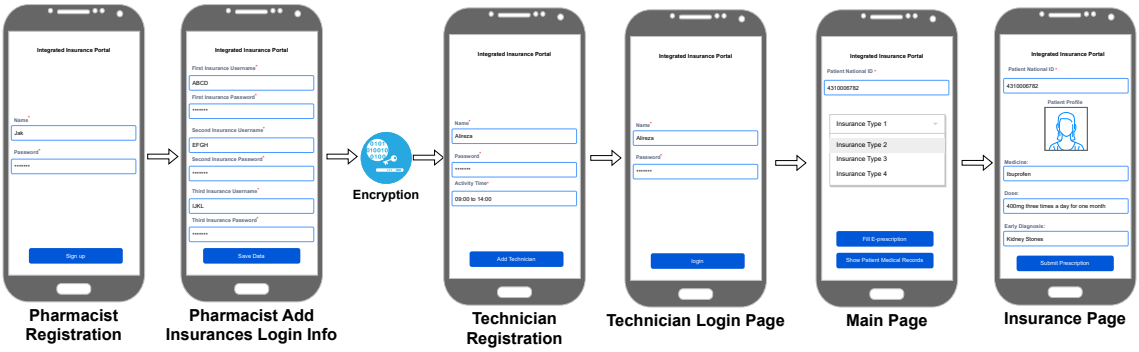



**Figure 6.7:** Use case 1: Need for Better Authentication blue print

## 6.7 Proposed Solutions for Need for Facilitating Finding Rare Medicine Use Case

During the second phase of our methodology (Need Assessment), we discovered that patients often struggle to find rare medicines, sometimes needing to visit multiple pharmacies to find their required medications. The Ministry of Health in Iran provides software for pharmacies and requests that they keep this database updated to inform patients where they can find their necessary medicines. This process is described in detail in the context analysis phase of the project, and we have provided a BPMN diagram (shown in figure 5.0.4)to illustrate how pharmacists inform patients about available medicines. However, after conducting interviews with pharmacists, we found that this solution by the Ministry of Health is no longer effective following the development of e-Health by insurance portals. Previously, pharmacists used the developed software (a global database named TTAC) as their warehousing program, keeping it updated after each patient interaction. But since the advent of e-Health development by insurance companies about two years ago, they no longer use TTAC as using two distinct software solutions and manually updating TTAC is time-consuming for them.

### 6.7.1 Use case 1: Addressing Need for Facilitating Finding Rare Medicine

Combining software systems may help minimize parallel efforts required from pharmacy technicians by developing an API or middleware solution between them. Pharmacists would then only need to amend information once in one location, minimizing human error resulting from duplicating steps when updating multiple databases concurrently. Also, automation could allow insurers' records on e-Health portals to automatically sync with TTAC's system, minimizing dual maintenance activities. Implementing such a collaborative effort would require involvement from interested parties, such as The Ministry of Health working closely with the IT team at both Insurance providers running e-Health portals and TTAC's developer camp. Collaboration efforts and adequate consideration of security and data privacy requirements would have to be in place to ensure the solution betters overall workflow while maintaining necessary levels of information confidentiality, availability, and integrity.

#### 6.7.1.1 Evaluation of Use Case 1: Facilitating Finding Rare Medicine

Based on the criteria introduced in section 6.2, we can see that integrating the Insurance portal with the TTAC can create a scenario where pharmacists can use an automatically

updated database. This would allow them to easily inform patients where they might find rare medicines. To connect these separate systems, it is required that both insurance and TTAC systems provide APIs, which would allow the implementation of an integrated system. Regarding the cost of development and maintenance, it is not a significant expenditure, and this parallel system can be developed at a low cost. In terms of security, it is important to ensure that the APIs are fully safe, even though we only need information on sold medicines and do not require any additional information like a patient's name. Since we are only working with this type of data, we can conclude that this solution is fully safe. In terms of development time, there is no need for complex development. The system simply requires APIs from all systems and a real-time updated database. Therefore, this solution can be categorised as a low development time solution. In terms of the stability of the solution, it can work for an extended period of time. As we discussed, TTAC worked smoothly before the implementation of the insurance portal for many years. Thus, we can conclude that if we can keep this database automatically updated by connecting to insurance portals, it will be stable and work for a long time. Regarding ease of use, this solution is completely straightforward and works automatically without any interaction from the pharmacist. Therefore, this solution is highly user-friendly. In terms of technical feasibility, unfortunately, this solution is not yet feasible since none of the insurance companies and TTAC have any API for this purpose until now. In terms of the legality of the solution, this solution is without any legal restrictions and can work easily since no patient data will be transferred throughout the system at all.

### 6.7.2 Use case 2: Addressing Need for Facilitating Finding Rare Medicine (DaroRahyab)

We could develop a patient-centric tool, suggested by one of the patients during an interview, that would allow patients to inform each other about the availability of rare medicines. This tool could be either a mobile application or a website, where patients can fill in a form either anonymously or with their own details and inform other parties about where and when they found a specific medicine. The system could then display the last time a pharmacy had a particular medicine available. Patients could add a reminder alarm and also search for rare medicine in this app.

It is expected that patients will keep this database updated, as they will also benefit from this tool themselves. Although there may be a risk that patients who inform could give false information, we can implement a ranking system where other patients can score those who provide accurate information. Similar to StackOverflow, we can introduce a

mechanism whereby verified patients receive a verification tick from other patients when they provide correct information. Even if the given information turns out to be false, patients can call a pharmacy to check the availability of a rare medicine before visiting. This tool can help narrow down the number of pharmacies to check, enabling patients to find their required medicine more straightforwardly. This tool allows patients to take an active role in the management of their health care, fostering a sense of community and shared responsibility. Since the tool relies on user-generated content, it may be updated more frequently and thus provide more current information. However, as the information would be user-generated, there may be inaccuracies. Even with a ranking system, false information can be an issue, and it could lead to frustration if patients go to a pharmacy based on incorrect information. The blue print of this idea is shown in the figure 6.8. The blue print is the high-level plan or outline depending on which the end product, that is the software, is going to build. It is worth mentioning that we developed this use case technically, and named it DaroRahyab. We discussed the development of this use case in chapter 7.

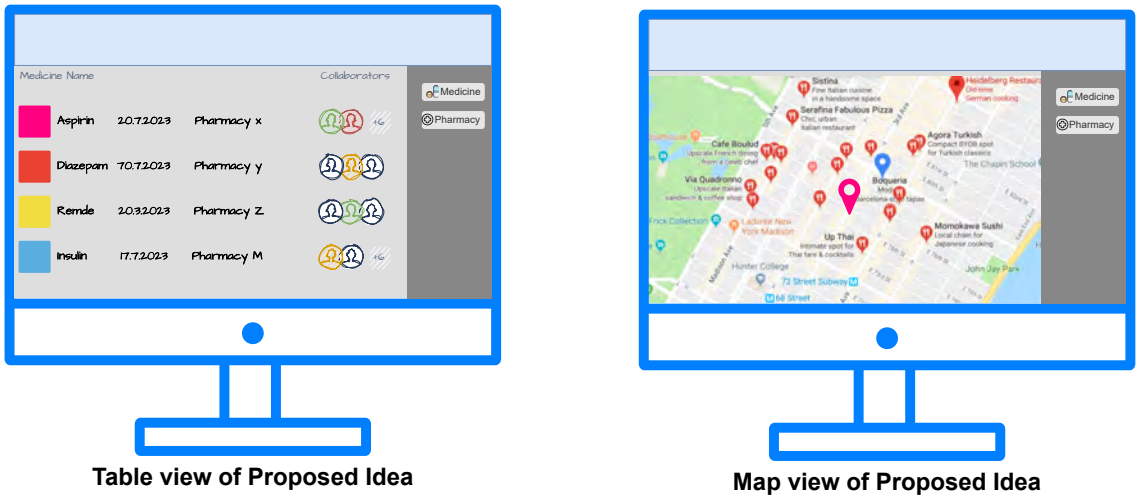



**Figure 6.8:** DaroRahyab (Blue Print)

#### 6.7.2.1 Evaluation of Use Case 2: Facilitating Finding Rare Medicine

Based on the criteria introduced in section 6.2, we can see that the development of a patient-centric application like DaroRahyab (either web app or mobile app) is not costly. This application can simply be a real-time database that allows patients to update and inform each other. Regarding the security of this application, complex encryption is not

required as we allow some patients to register under their own names to prevent spamming. However, the application must be secure enough to prevent misuse of patient data and data manipulation. As for the development time of this application, we anticipate it to be fairly straightforward. It may take time to deliver a high-speed application that can display a map of all rare medicines. Thus, we categorise the development time for this application as moderate. In terms of the application's stability, it largely depends on user collaboration, and we cannot predict whether users will continue using this app in the future. It is plausible that if Iran resolves its sanctions issues and can easily import rare medicines, patients may no longer need this application. Regarding ease of use, we can affirm that this app is very user-friendly, even for patients who lack computer literacy. They just need to type the name of the medicine for adding or searching for medicines. In terms of technical feasibility, developing this application aligns with the current IT infrastructure of the country, and we do not need any complex technical assets. Concerning the legality of the application, we predict it will be legal, as we offer users the option to use our application anonymously.

### 6.7.3 Prioritization of Use Case for Need for Facilitating Finding Rare Medicine

Based on our evaluations of the two distinct proposed use cases using the criteria introduced in section 6.2, we can conclude that the second solution namely DaroRahyab- the patient-centric application - is more suitable for the current situation. This is primarily due to the fact that none of the insurance companies currently provide APIs, and no one can compel them to offer this feature. Even though the medicine shortage started many years ago, it is not a permanent challenge and could be resolved in the future. Therefore, a long-term solution is not necessarily required. The second solution, the patient-centric application, can easily satisfy users' needs under the current circumstances. Finally, we developed the second use case, namely DaroRahyab and discussed its developments and verification phase in chapter 7.

# 7

# Development and Verification

In this phase of research, we delve into the technical aspects of developing the proposed ideas. After formulating artifacts based on the key stakeholders' needs and the current IT infrastructure in Iran, we set about developing the most suitable ones. If more than one artifact was created to address key stakeholders' desires, we employed a set of criteria to evaluate each artifact, prioritizing the most suitable one based on the current circumstances. Also, we asked key stakeholders' opinions about our resulted applications and received positive feedback and verified our developed applications.

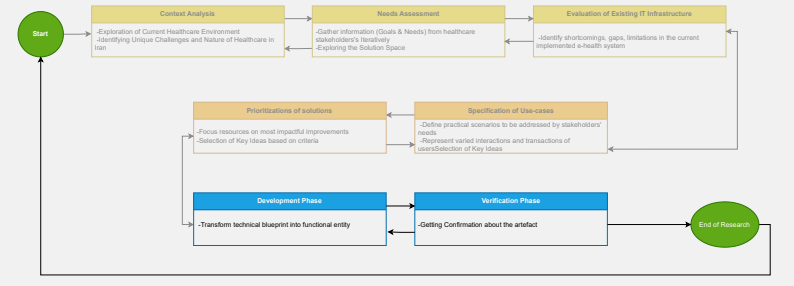



**Figure 7.1:** Development and Solution Evaluation Phase (Fifth step of methodology)

## 7.1 Development of New Login Page for Integrating e-Presentation Systems (DargahRahyab)

To facilitate the e-prescription system for both doctors and pharmacists, we have added an extra layout to the current e-prescription system. This additional layout enables pharmacists and doctors to sign up for our application locally and enter all their insurance portal passwords just once. From that point forward, they only need to select the insurance type and the patient's national ID. Our application then automatically redirects them to the

relevant insurance websites and logs them in. Given the significant priority we place on user security and privacy, we have added several measures to ensure all data is securely saved. It is important to note that all data is saved locally on the device used by the pharmacist or doctor, and we never transfer any data to any online database to ensure maximum security. After signing up, we encrypt all usernames and passwords with a private key, which is the device processor ID. Each time we need this data, our application decrypts the information. To ensure that only the device's owner (the doctor or pharmacist) has access to this application, we have added biometric authentication.

### 7.1.1 Encryption Method

An Advanced Encryption Standard instruction set is now integrated into many processors. The instruction set aims to improve the speed and security of applications performing encryption and decryption using the Advanced Encryption Standard (AES). They are often implemented as instructions for a single round of AES and a particular version for the last round with a slightly different method. Our application employed this method to save and retrieve all the data securely. Even though our data save locally, we must be sure that other installed applications on doctors' and pharmacist devices do not have access to our data for any data manipulation.

### 7.1.2 Biometric Authentication

Since we save the login data of pharmacists and doctors on their used devices, it is essential to ensure that nobody with access to these devices can access this application and saved data. We have added a biometric authentication functionality (if the device supports it) to ensure that everything is safe and that nobody can misuse the data. For IOS version of the application we employed Face Id, whereas we used Fingerprint for Android Devices. We alse used fingerprint for Mac OS version.

### 7.1.3 Used Programming Language for Development

In this master project, we decide to use Flutter framework as the primary developing language to prepare our use case. The first and foremost reason was that Flutter is to provide cross-platform support. In other words, using this programming language allows us to develop Android, IOS, and Mac OS versions from a single codebase, and we need to change a few things, like the user experience part for each platform. If there is a need for an update or bug fix, the changes need to be implemented only once, reducing maintenance

efforts. Although this programming language is not precisely fast as the native version like Objects C, Swift, java, or Kotlin, there is not such a significant difference in the scale of our project. The high performance of Flutter Framework ensures a smooth user experience, which is particularly important for tasks like biometric authentication and data encryption and decryption. Flutter provides easy integration with advanced technologies like biometric authentication and AES encryption, critical features in our application. Due to mentioned reasons, we employed this programming language to develop our application. Some screenshots of developed applications can be seen in figure 7.2.

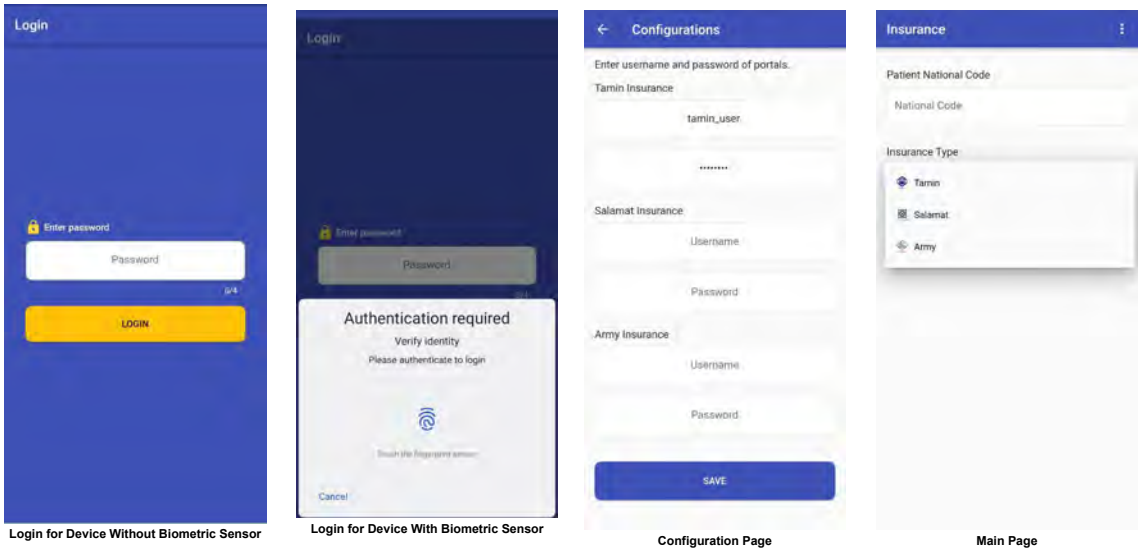
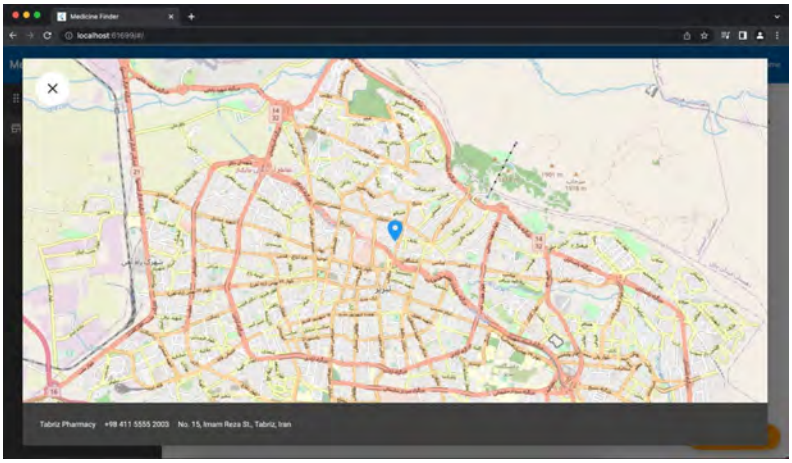



**Figure 7.2:** Screenshot of Developed Application of New Login Page for Integrating E-presentation Systems (Namely DargahRahyab in Persian)

## 7.2 Development of Web Application for Finding Rare Medicine (DaroRahyab)

To facilitate finding rare medicines for patients, we developed a patient-centric web application that allows patients to inform each other about the availability of these medicines. Previously, pharmacies were responsible for keeping an updated database, which other pharmacies could refer to regarding unavailable rare medicines. However, with the advent of e-prescription development in Iran by insurance companies, pharmacies found maintaining this database challenging and time-consuming. Since the Ministry of Healthcare developed this database and it is not integrated with the insurance portals, pharmacies must manually update it after preparing each patient's medicine. To address this issue,

we decided to shift this responsibility to the patients, enabling them to assist each other. They can inform other patients when they locate a rare medicine. With the help of Flutter, we developed a web application where patients can take on this responsibility and inform others. This application can display data regarding the reporter's last availability, location, and reliability. We have a feature where other patients can give a score when they find a truthful update about a rare medicine. This approach works similarly to Stack Overflow websites, where verified comments are visible. Some screenshots of this developed use case can be seen in figure 7.3.



**Map View of Web Applications for Finding the Rare Medicine**

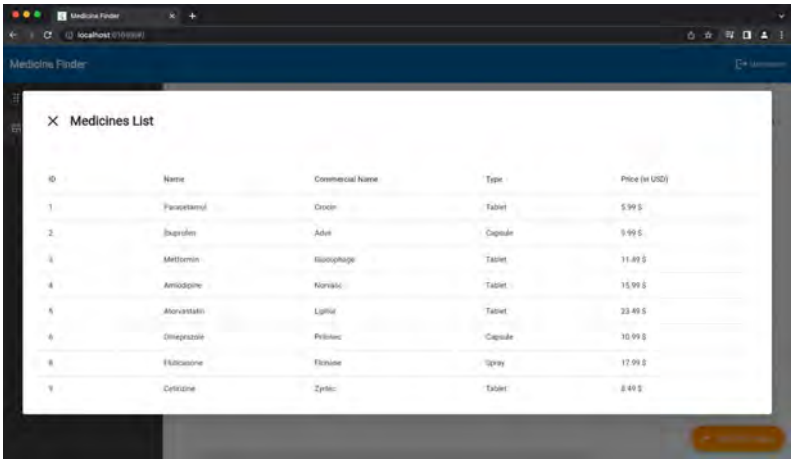



**Table View of Web Applications for Finding the Rare Medicine**

**Figure 7.3:** Screenshot of Developed Application for Finding Rare Medicine (namely DaroRahyab in persian)

## 7.3 Verification of the Developed Applications

We showed the result of our work to our key stakeholders, including doctors, pharmacists, and patients, to be sure whether the proposed designed solutions were based on their expectations. We discussed a general Practitioner, a pharmacist, and two patients between 20 June 2023 and 27 June 2023 and asked whether this solution and developed applications suit your needs or not. Hopefully, we received positive feedback; almost all of them found these solutions productive and beneficial. One patient was worried that she did not want to share her consumed medicine with other people with her name and became angry. After we explained that she could anonymously update our database for a patient-centric application, she was satisfied with our solution. The general practitioner was such satisfied that ask us to deploy our solution in her medical center in Tehran capital of Iran. We can conclude that our designed solutions are based on stakeholders' needs.

# 8

# Discussion

## 8.1 Research Limitation

The master's thesis, conducted in the ICT4D field, faced some limitations. Firstly, the study relied on stakeholders who were sometimes unaware of their requirements. This limitation potentially affected the accuracy of the data collection, and we had to conduct too many interviews to determine their needs. The process of data collection faced additional challenges. During the period of conducting interviews, Iran was experiencing severe internet connection problems, complicating our reliance on various platforms such as Skype, Zoom, and WhatsApp. Adding to these challenges, the health workers from Iran's public health sector exhibited concern about sharing information due to the sector's strict policies. This fear potentially affected the depth and scope of the collected data, leading to potential gaps in perspectives in the results. To tackle with this stakeholders' fear, we had to conduct too many interviews to get enough information.

# 9

# Conclusion

In conclusion, we used requirements-engineering-based methods to broadly analyze and understand the context of e-Health in Iran with stakeholder interviewing, IT infrastructure evaluation, conceptualizing the findings from the interviews using BPMN, and prototyping in an iterative process. Following this, we narrowed down our findings and discovered stakeholders' requirements based on the broad context analysis and understanding of Iran's e-Health complexity. Then we transitioned to the technical approach and developed two user-centric applications based on the key stakeholders' requirements for specific use cases. DargahRahyab application developed to simplify the login and integrate the portal and DaroRahyab assist patients in rare medicine finding. We applied our adopted methodology to address our two research questions.

Research Question 1 was, "How can we analyze a complex context such as healthcare in Iran to understand the state, challenges, and limitations of e-Health in the country?". As a result of detailed analysis and applying a Knowledge approach, we understand that unique challenges exist in Iran's e-Health system, including international economic and technological sanctions, brain-draining, cyber threats and data privacy issues, and high dependency on private sectors. Answering this question gave us an understanding of the complex context of e-Health in Iran with specific circumstances, and we used this understanding to discover stakeholders' requirements in the following step.

Research Question 2 was, "How can we identify the needs and requirements of stakeholders in the health sector to design appropriate user-centered e-Health solutions within a complex context, such as the Iranian healthcare system?" By applying our designed method, we identified the stakeholders' requirements, like the lack of an integrated e-prescription system and patients' challenges in finding rare medicine.

## 9.1 Project Assets

Since some interviewees requested us to keep their names and identification anonymous, we decided to keep the interview transcript and recorded files in our private GitHub repository beside our project files. If you need to access this data, we can ask interviewee for permission and then share on specific conditions. Please contact us if you have any questions or need the project code by the below personal email. Also, you can freely access the presentation file, which is located in the below google drive link.

Personal email address: ar.soltaninezhad@gmail.com

Slide on Google Drive: Open Presentation Slides on Google Drive

Link to GitHub: https://github.com/alireza-soltaninezhad/Master_Thesis_Project_2023

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