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"Implementing Automated TDABC In Healthcare Settings - Crafting a Strategic Roadmap for a Seamless Implementation and Interoperability"

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Abstract

This work project outlines a meticulous strategy for the successful implementation and interoperability of Automated TDABC in healthcare settings. Anchored by a fusion of RFID technology and process mining, our innovative approach streamlines data collection and process mapping. Drawing insights from academic literature, medical professionals, and industry experts, we emphasize the superiority of TDABC over conventional costing methods. Additionally, we delve into the integration of TDABC with FHIR, ensuring alignment with contemporary healthcare data exchange standards. Recognizing the legal landscape, our exploration incorporates considerations of the legal framework surrounding the implementation of our solution. Following this, we also present a possible business model. Finally, our work concludes with a discussion of the advantages and limitations of our solutions and provides strategic recommendations for overcoming the main challenges.

Keywords

Time-Driven Activity Based Costing, Value-Based HealthCare, RFID, Process Mining, PM4PY, FHIR, GDPR, HIPAA, VBHC, TDABC

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1. Introduction

While the theoretical foundations of Time-Driven Activity-Based Costing (TDABC) in the framework of Value-Based Healthcare (VBHC) are robust, its practical implementation within healthcare organizations is often tied to challenges related to achieving accuracy in cost tracking and precise time measurement. Equally important and challenging is ensuring that introducing TDABC within a healthcare setting does not increase doctors and employees' workload, which is generally already very high (Kaplan, 2016). Such obstacles highlight the need for an innovative, automated comprehensive approach capable of addressing the discrepancies between theoretical models and the unpredictable realities of healthcare environments.

Following this direction, **this work project moves beyond traditional approaches, and presents an end-to-end solution tailored to empower healthcare organizations to implement and automate Time-Driven Activity Based Costing.**

Central to our innovative solution is the integration of RFID and process mining technologies in healthcare settings to automate and streamline activity cost tracking and process mapping.

Moreover, in order to refine and validate our solution, we have conducted interviews with medical doctors, researchers, and different professionals who operate within the realm of the healthcare industry. Their invaluable input, grounded in their first-hand experiences and academic rigor, is placed at the core of our proposed solution.

Our work begins with an overview of the current challenges and limitations of traditional approaches in the context of healthcare cost management. Then, the Value-Based Health Care Framework is introduced, highlighting the increasing need for precise cost tracking and measurement in healthcare institutions to improve the value delivered to patients. Once the context and scope of our work is defined, we introduce the TDABC method, as formulated by

Kaplan and Anderson, suggesting it as a potential solution to several of today's healthcare organizations. After laying out these core concepts, a detailed and comprehensive strategy for the implementation of TDABC in a hospital setting is presented, while also addressing the key steps to overcome the main challenges that organizations might face across all phases of the implementation. Complementarily, a careful analysis of the requisite technologies essential for ensuring a seamless process implementation is undertaken. Finally, this work projects ends with the detailed business model we intend to adopt when offering our solution to organizations, and with an overview of the current limitations, required investment and timeline for the full implementation of TDABC.

2. The need for a comprehensive solution

2.1 The importance of cost containment in the healthcare industry (Group Part)

Cost containment in healthcare is defined as a reduction in costs while maintaining or enhancing the quality of services, a principle articulated by Weinstein and Stason in 1977. This approach is thought to be crucial for increasing health system efficiency. It involves strategic management and control of the escalating costs associated with delivering medical services, addressing challenges posed by technological advancements, an ageing population, and the growing demand for quality care in the healthcare industry.

The importance of cost containment extends beyond the organizational level. A well-designed healthcare cost-containment strategy can provide societal benefits. Limiting excess spending that adds little value, contributes to more efficient resource allocation. This, in turn, prevents the crowding out of valuable government expenditures, upholds solidarity principles in healthcare, and enhances the overall efficiency of spending (Stadhouders, 2019). The goal is to strike a balance where cost reductions do not compromise the quality of care but rather lead to a more effective and sustainable healthcare system.

2.2 Gap in existing approaches and the need for a comprehensive solution

Historically, the methods employed in managing healthcare costs tend to fall short in effectively addressing the complex challenges faced by healthcare institutions. While diverse methodologies have been deployed to address specific facets of cost optimization, a predominant issue lies in the lack of a systematic and comprehensive approach that is indispensable for achieving optimal operational efficiency. This gap becomes particularly apparent in the context of the TDABC subject, where the complexities of healthcare operations demand a more sophisticated solution.

As previously mentioned, many existing approaches in healthcare cost management often exhibit a fragmented nature, focusing on isolated facets such as direct medical expenditures or specific operational processes. They tend to lack the granularity required to track costs comprehensively across the entire patient care continuum. This fragmented approach results in a limited perspective on the overall cost scenario, creating gaps in understanding how various activities contribute to the broader financial picture.

In fact, such methodologies mostly rely on broad estimations or generalized allocations, department-centric accounting, and simplified cost estimation techniques that fail to offer detailed insights into where costs accumulate within various care pathways. Consequently, healthcare organizations struggle to identify the specific areas where costs are incurred, hindering efforts to optimize resource utilization and operational efficiencies.

There is no doubt that healthcare operations involve a multitude of interconnected activities, each with its cost implications. The failure inserted in traditional approaches alone standing, reaches to the pressing need for an end-to-end solution capable of addressing all these challenges comprehensively. There is the need for a unified system that automatically integrates data sources, streamlines cost-tracking mechanisms, takes usage of sophisticated analytics and

reporting, all aligned with value-based care principles. TDABC, specifically and automatically tailored for the healthcare industry, would be a commendable start, given that it offers a more sophisticated lens through which institutions can analyze and optimize costs, providing a holistic understanding of the interconnected nature of healthcare activities and their financial implications.

Substantial evidence indicates that the lack of a comprehensive solution contributes to overutilization and misuse of technology (Brownlee et al., 2017), leading to excessive spending that may not align with the value delivered to patients.

The gap becomes even more apparent when considering the imperative of transparency in cost allocation, resource consumption, and understanding cost drivers. The limited insights provided by current approaches hinder healthcare administrators from fostering informed discussions and making strategic decisions that are essential for efficient cost management.

A comprehensive approach is necessary to address the current gap in healthcare cost management. Getting a clear picture of expenses, assigning specific tasks to people, and being open about how resources are used are all crucial aspects. With such a solution, healthcare organizations would be able to spot inefficiencies, deal with high-cost areas, and allocate resources wisely. In order to maintain cost reduction and enhance service quality procurement, this strategy facilitates the development of realistic financial projections, successful contract negotiations, and streamlined workflows. The shortcomings of the traditional methods used emphasize the need for a more exact and sophisticated approach to maximize healthcare cost control.

Relevance of Automation

Complementary, it must be emphasized the utmost importance that automation components have in the contemporary healthcare landscape. No comprehensive solution should be considered without incorporating automatic developments. It is an imperative. An automated process fully imbibed in such solution can ensure a seamless flow of data collection, processing, and analysis, thereby granting the healthcare industry instrumental real-time insights into critical aspects such as cost drivers, resource utilization patterns, and care pathways.

Such arguments have been highlighted in a study by Blumenthal and Tavenner (2010), emphasizing the significance of Electronic Health Records (EHRs) and their role in improving healthcare quality and efficiency. Additionally, it is also argued that automation in healthcare systems not only enhances operational efficiency but also contributes to improved patient outcomes (Zayas-Cabán et al., 2022). It is further claimed that automation, in conjunction with advanced analytics, facilitates evidence-based decision-making for healthcare administrators (PricewaterhouseCoopers (PwC): “Global Top Health Industry Issues 2021”). Such advancements are also critical in meeting the increasing demand for personalized care, being technology an important vehicle to achieving patient-centered care models (Naserias et al., 2015).

2.3. Proposed Solution

2.3.1. Overview

The main objective of this work project is to present a detailed plan for the implementation of automated TDABC within the complex landscape of healthcare settings. Transitioning from the theoretical groundwork and conceptual frameworks previously discussed, we now direct our

attention to the actionable strategies and critical considerations necessary for practically guiding hospitals through the adoption of TDABC.

Taking into consideration the constraints of traditional cost measurement methods outlined earlier and identifying the subsequent market need for a comprehensive solution, we propose an advanced solution to suitably address this gap. Kindly note that this solution comprehends the use of significant technical technological components that may pose challenges in comprehension. However, rest assured that each element will be meticulously explained, ensuring a clear understanding without any ambiguity.

Without further do, our proposed solution starts with a thorough facility and patient mapping through the usage of Radio-Frequency Identification (RFID) technology, namely wristbands and sensors for an effective real-time tracking. The secure storage provided by the Fast Healthcare Interoperability Resources (FHIR) database enables process mining tools to examine patient pathways and workflow effectiveness. This synergy identifies the costs incurrence from a bottom-up perspective, which maximizes resource allocation and operational efficiency by giving administrators relevant insights for well-informed decision-making. In addition to streamlining present procedures, our scalable approach that combines RFID, FHIR, and process mining also establishes the groundwork for upcoming advancements in healthcare, building a networked ecosystem that enhances patient care and boosts organizational efficiency.

Before diving deep into the technical specifics and practical implementation requirements of our solution within healthcare institutions, we provide an introduction of the two key technologies - RFID and Process Mining - that contribute to making our proposal highly innovative yet feasible.

2.3.2. Key Enabling Technologies: RFID Technology

Radio-Frequency Identification (RFID) represents a pivotal technology within the realm of wireless communication and data capturing systems. In an RFID system there are two main devices: the tag, also known as a transponder, and the reader, or interrogator. Fundamentally, RFID is a technology that utilizes electromagnetic fields to transmit information from the tags to the readers. As RFID tags are essentially small transmitters, they are capable of collecting data about the item or person to which they are attached, and then convey this information to the reader once they are within range (Want, 2006).

In the last decade, the use of RFID technology has found applications across various industries due to its accuracy in tracking and managing inventory, assets, and resources. Especially in the field of supply-chain, RFID devices have been extensively adopted for several years. For example, Walmart, currently the largest retailer across the world, effectively adopts RFID tags to accurately track its moving inventory and improve the overall efficiency of its value chain. (Angeles, 2005). For what concerns the healthcare industry, the potential of RFID technology has started to gain considerable recognition only in recent years. Initially, applications of RFID technology in the field of healthcare were limited to pharmaceutical companies and medical device providers, that leveraged the tracking capabilities of RFID mainly to minimize waste and monitor potentially fraudulent activities (Yao, Chu, & Li, 2012).

However, the capabilities of this technology have advanced over the years, becoming increasingly more cost-efficient and widespread. Use cases such as error prevention, theft prevention and inventory management have emerged and have been successfully implemented. According to Abugabah et al (2023), the most common objective for tracking staff and medical equipment is to improve patient safety by ensuring correct infection control. Mostly, hospitals track their staff to ensure they comply with hygiene regulations such as hand washing. In

addition, safety is another issue when implanting the device in a patient. RFID is used to ensure that the correct device is implanted in a patient and is overall an important aspect to promote safety. The patients are tracked to drive ward efficiency and cost per patient by predicting patient movement and bed utilization. Overall, safety, efficiency, and cost savings in the supply chain are reasons to implement RFID technology (Abugabah et al, 2023).

According to a report by Grand View Research, the global medical RFID market is expected to reach a global market size of USD 14.65 billion by 2030, growing at a Cumulative Annual Growth Rate (CAGR) of 17.85% from 2023 to 2030, as reported by Grand View Research (2023). This positive trajectory opened the doors to new opportunities in the adoption of RFID devices to automate the tracking of activities and resource utilizations within hospital infrastructures. In this context, RFID can be exploited as enabler technology to implement automated TDABC within a hospital.

2.3.2. Key Enabling Technologies: Process Mining

First introduced by Van der Aalst, process mining combines data mining with machine learning techniques. Through pattern recognition, process mining identifies process flows which include the sequence of events, timestamps, and allocated resources (Dallagass et al, 2022). In the healthcare landscape, the resulting output is a diagram that visualizes the care pathway of a patient with a certain condition.

Many researchers have studied the application of process mining in healthcare settings. There are studies applying process mining to emergency care, cardiovascular disease, oncology, stroke, and sepsis, creating distinctive care pathways for conditions. These care pathways provided a good foundation to test process improvement and their effect on patient outcomes (Litchfield et al, 2018). Dallagass et al (2022) further investigated the different applications of process mining in the healthcare setting. In their research, they found that 35.5 % of the

applications involved identifying activities to establish or update protocols and clinical guidelines. 24.8 % were concerned with analyzing and optimizing resources as well as evaluating health technologies. The remaining use cases involved compliance analysis, evaluating discovered process models against prevailing clinical guidelines and protocols for standardization purposes; and conformity analysis, with the aim to evaluate whether a specific patient's journey adheres to the clinical guideline for a specific illness.

The use cases for process mining have increased over the years and the technology itself is continuously improving with new algorithms emerging over the years. According to a report by Markets and Markets (2023), the global market for process mining is expected to expand from USD 1.8 billion in 2023 to USD 12,1 billion in 2028, growing at a Cumulative Annual Growth Rate (CAGR) of 45.6% from 2023 to 2028.

Although there are many applications for process mining in healthcare, there is yet a study to be found that has the goal of implementing TDABC in healthcare organizations with the help of process mining techniques. Hence, we see a gap which we can fill to implement automated TDABC in hospitals.

3. Methodology: Validity and Reliability

The approach presented in this paper lays its foundation in the available academic research in TDABC, and links it with the reality of today's healthcare industry. In fact, this work project has sought validation from the "front lines": key stakeholders such as MDs, PhD candidates, Process Mining experts, and professionals with hands-on experience in similar projects were interviewed and involved in the creation of our solution. Their insights and feedback have been invaluable, helping to refine and validate our proposed approach. Our methodology is a mixed method exploratory research, using primary research methods, i.e. interviews, and including secondary research by gathering data through existing literature and online sources.

3.1 Primary data - Interviews

We conducted semi-structured interviews to be able to adapt the questions according to the expert's expertise and professional experience within the different aspects of our project. In a first step, we identified key stakeholders who were involved in projects with the goal of implementing TDABC or process mining in a healthcare setting. We used LinkedIn and e-mail as tools to contact them and ultimately conducted five interviews. Before each interview, we prepared questions tailored to the expert's background and area of expertise to receive insights for a specific part of our solution. The interviews were conducted online via MS Teams for the duration of 30 to 60 minutes. The interviews were scheduled in the time frame between October 11, 2023 and November 10, 2023.

The interview partners are experts in different fields related to our solution from Belgium, Norway, and Brazil. The professional backgrounds range from MD, researcher, professor to specialist. Three of the interviewees had been involved in projects regarding implementing TDABC in hospitals manually. Niels Hilhorst from Belgium has worked as a MD at the University Hospital of Gent (UZ Gent) when he implemented TDABC for the condition of psoriasis. Erin Roman is a phD candidate and researcher at UZ Gent. She developed process maps and implemented TDABC in two disease domains, namely breast cancer and psoriasis. Joke Borzée, also a phD candidate and researcher at UZ Gent, implemented TDABC manually in several hospitals in the conditions of lung cancer, psoriasis, and hip surgery. Another expert that we interviewed is Anton Hasselgren from Norway. He has a profound expertise in blockchain technology in healthcare settings, being a blockchain specialist at Accenture. Eduardo Alves Portela Santos, who is a professor at the Federal University of Paraná in Brazil, has been involved in several process mining projects and is considered a thought leader in process mining (Table 1).

3.2. Secondary data

Alongside the interviews, we used secondary data. We mainly used Google Scholar and EBSCOhost. EBSCOhost provides very tailored results as one can select specific databases. This narrows down the search to journals and papers that are in the domain of interest and gives adequate results. Hence, by combining rigorous academic exploration with professional expertise, we ensure that our methodology is not just theoretically sound and reflects the state-of-art, but also practically viable and ready to make a significant impact in the healthcare cost management landscape.

4. Implementation of Automated TDABC In Healthcare: Our End-to-End Solution

In this section, we present the technical specifics and practical implementation requirements of our automated TDABC end-to-end solution within healthcare institutions. This proposition follows the insights received through our interviews and research. First, we empathize the relevance of automation throughout the implementation process, which plays a crucial role in enhancing precision and consistency, essential for effective cost tracking. Next, we deep dive into the reasons that make RFID the most effective technology to adopt in our proposal, highlighting the role it plays as an enabler in implementing and automating TDABC. Then we explain how we deploy process mining to create care pathways automatically, which is an essential step to identify the resources and time spent for each resource as a prerequisite for TDABC. Lastly, we address data collection and privacy concerns. Adhering to EU standards, our approach ensures safety and confidentiality in the management of patients and personnel information, ensuring both compliance with the most stringent regulations, and accuracy of the collected data.

4.1 Role of automation

As previously highlighted, the incorporation of automation components into our solution stands as a crucial imperative. This argument that sustained and concerningly emphasized during our meetings with field experts.

Throughout the conducted expert interviews, a recurring sentiment emerged among medical professionals: a reluctance to adopt TDABC or any new approaches if it implies that their administrative burden will increase. According to the estimates of an MD interviewed, administrative tasks already consume 20 % of a physician's time; thus, the willingness to spend even more time on such topics is considerably low. Moreover, both nurses and doctors expressed discontent in their manual data collection experiences within care pathway creation projects, citing that is too time consuming. Another interviewee confirmed that there is a keen interest in TDABC, but that the manual approach would be too time-consuming for it to be implemented. A third interviewee who was involved in projects of implementing TDABC in breast cancer and psoriasis described time to be one of the biggest challenges. In her projects, in which she used the observation approach, the MDs had little time. According to her, even if she was lucky, she could see a MD for no more than 20 minutes in an entire day. It was challenging for her to find a MD who was invested and committed to provide time. She highlighted that it is important to note that it does not suffice to have only one interested medical doctor but that it would require at least seven to eight committed medical doctors to enable the implementation of TDABC, which makes the success rate even less likely.

We have observed that the biggest challenge from several stakeholders who implemented TDABC with the manual approach was that MDs lose interest in committing to the project once they find out how much time investment is required from their end. Hence, automating the

process of gathering data and mapping the care pathway seems to be necessary to lift this burden from the MDs to receive their commitment.

In the following sections, we will discuss how RFID technology enables us to gather necessary data, meticulously tracking resources - encompassing MDs and other medical staff - and precisely documenting their time spent on each activity. Subsequently, after having gathered the data, we venture into automated care pathway discovery using process mining technology. This provides a panoramic view on resource utilization and time spent per resource throughout the entire patient journey; hence, streamlining the implementation of TDABC with minimal manual intervention. This integration of automation emerges as a tool for overcoming resistance to new methodologies among healthcare professionals. By minimizing their involvement in the labor-intensive aspects of data collection and analysis, it allows medical staff to focus on their core competencies, which is delivering quality patient care.

Moreover, automation not only addresses the primary concern of time-consuming manual data entry, but also ensures consistency and accuracy in the gathered data, which are crucial for effective cost analysis and process optimization. In the context of implementing TDABC in a hospital, automation transcends mere data collection, and it represents a transformative shift towards a more efficient, accurate, and sustainable model of healthcare cost management. By leveraging technologies such as RFID and advanced data analytics, healthcare institutions can significantly reduce the administrative burden on medical staff, thereby enhancing their engagement and willingness to adopt TDABC methodologies. This not only enables organizations to streamline processes, but it also aligns with the broader objective of improving healthcare delivery efficiency and patient-centric care.

4.2 RFID technology

RFID technology is widely used in many industries. In the healthcare environment, RFID technology is implemented to track medical staff, patients, and medical equipment (Abugabah et al, 2020). Abugaba et al (2023) show that healthcare organizations adopt RFID technology depending on factors such as perceived benefits, market uncertainty and the presence of champions. Other variables that determine the implementation of RFID include costs, security, and top management support. This is important to consider so that we can estimate the benefits of using RFID.

Alternative technologies that are used to track people and equipment include Near-Field Communication (NFC), Bluetooth Low Energy (BLE), and Real-Time Location Systems (RTLS). NFC is a wireless communication technology and connects a tag to a compatible device within a short range of 1-10 cm. Due to its short rage, the person or equipment needs to come into very close contact with the reader to be tracked, which often requires action (Singh, 2020). In comparison, RFID has a wider range of 3-5 m. Another advantage of RFID compared to NFC technology is that the RFID reader can detect multiple tags compared to a single tag at a time (Oliveira, 2022). That is crucial as we have several tags that need to be tracked at a time such as medical equipment, drugs, medical staff, and patients. BLE is a low energy wireless device that enables communication with a large number of devices. Even though BLE devices have a wider range, RFID tags are less expensive. As we will allocate a reader in every room, the range of RFID is more than sufficient (Kumar et al, 2021). RTLS systems consist of a global wireless network of location infrastructure and RFID sensors and tags. It has a better location accuracy over a greater range, whereas the accuracy of RFID decreases as the tag gets further away from the reader. However, as previously mentioned, this is not an issue as the reader is in the same room, thus, will be in proximity. Moreover, RTLS systems are more challenging to scale due to their complex infrastructure and higher costs (Bing Wang, 2013).

Overall, we choose RFID due to its ease of implementation, sufficient range, and low cost of devices. Moreover, it is effective at recognizing individuals and medications and efficient due to its capability of reading multiple tags at once (Abugaba et al, 2023). Another reason for using RFID is the willingness to implement RFID technology. Healthcare organizations are likely to adopt RFID as they have seen many use cases and their positive influence on healthcare organizations. Thus, we consider the barrier to implement a solution using RFID as relatively low.

Notwithstanding, like any technology, RFID systems present certain challenges. As highlighted by Abugabah et al. (2020), these challenges include high system implementation costs, operational complexity, lack of technical expertise, knowledge in utilizing RFID data, and security issues security concerns regarding patient and staff tracing and tracking if sensitive information is compromised. Therefore, when designing and implementing the RFID system, these limitations should be proactively addressed.

In the forthcoming sections, specifics will be provided on the customization of RFID components tailored for our solution's implementation and how the previous mentioned challenges could be tackled.

4.2.1 Passive and active RFID

RFID systems include two main categories: active and passive. Active RFID tags are equipped with a battery that provides power to the microchip's circuitry and enables the transmission of a signal to an RFID reader. These tags are typically larger, have a more extended range, and can transmit data over tens of meters. They can hold more data and are more reliable in challenging environments with high levels of interference (Engels, 2002). In contrast, passive RFID tags operate without a separate external power source and instead derive power from the reader

itself. These tags, relatively smaller and cheaper, have a shorter read range, usually within a few meters, which can be considered sufficient for many applications (Landt, 2005).

In a hospital setting, passive RFID systems hold advantages over active systems because they are significantly less expensive than active tags and can be disposable, which is particularly useful for patient wristbands and tagging single-use medical instruments, reducing the risk of cross-contamination (Bosch et al., 2015). The limited range of passive tags can be advantageous in a hospital environment as it reduces the likelihood of signal interference and unauthorized reading. This provides a more secure and precise location tracking within confined areas such as patient rooms and medication storage areas (Fisher & Monahan, 2008). Passive RFID systems are more durable and require less maintenance than active systems because there are no batteries to replace (Yao et al., 2012). The infrastructure required to support passive RFID is typically less complex and can be integrated into existing hospital information systems with relative ease. This integration capability allows for the potential automation of data entry into Electronic Health Records (EHRs), minimizing administrative workload and the possibility of human error (Bosch et al., 2015). Hence, we choose to implement a passive RFID system.

A little detail worth mentioning is that our solution will focus on the use of RFID wristbands for both patients and hospital staff. These wristbands are equipped with a smart tag composed of an RFID chip and antenna, functioning identically and serving exactly the same tracking purpose of an RFID tag. The key difference lies in their suitability for human wearability and comfort.

4.2.2 Implementation & Strategic Placement of RFID tags and readers

In addition to choosing between a passive and active system, we must consider how to place the readers and tags strategically to reduce the operational complexity. In 2004, the Washington Hospital Center in Washington D.C implemented RFID readers in hallways and in Emergency

Rooms. The Washington Hospital Center used ultra-wide band tags to track medical devices in the hospital. Both the hospital staff and patients wore credit card sized RFID tags (Abugabah, Smadi, Houghton, 2023). Likewise, for our solution, hospital staff and patients should wear RFID wristbands to receive concrete data on the resources.

The interviews confirmed the common perception that medical staff have limited time and capacity to commit to administrative work. An interviewee explained that the administrative workload increased during the last 10 years, which is why healthcare professionals, particularly nurses, are not likely to cooperate if the RFID system requires significant additional work for them, at least with the current incentives for them. This is crucial to consider when placing the readers.

The interviewees also addressed the question concerning granularity. Having the time stamps for the scheduled activity might be sufficient, but one must also consider that other activities might be undertaken in the same room. For instance, nurses might provide a consultation in the consultation room, but they also might conduct a part of the physical exams in the same room. This is problematic because in the case of several activities happening in a certain room at a time, the information about how much time each specific activity took would be vague in that case. In that scenario, a scanning system at the entrance of the room would not suffice if we wanted to allocate the exact time spent for each activity. To solve this issue, the medical staff would have to scan their wristband whenever they dedicate themselves to a new activity so that it is tracked that an activity has ended and a new one is being done. However, this is time-consuming and not effective as medical staff might forget to do it.

According to the interviewees, an attribute that facilitates allocating certain activities to patients is the fact that certain activities are usually located and conducted in the same one or two rooms.

The place where certain examinations take place is quite standardized. The same applies to scan machines which do not get moved and are only available in predetermined rooms.

Hence, we suggest placing the readers at the door so that the resources can be tracked immediately with no additional effort from the staff. Once the patient and medical staff enter the room, the time and the activity are tracked. To avoid multi-functional use of rooms, we consider it essential to discuss with the hospital management level how to implement distinct functions for certain rooms. As a patient could sit longer in the room while the MD has already left, both medical staff and patients wear the RFID wristbands at all times. Thereby, this enables us to track the exact duration of time spent of the MD or other medical staff on a given patient, making it more traceable which resource was used at what times.

Implementing the RFID System

To launch the project successfully, two interviewees mentioned that it is important to involve not only management, but the field people, meaning medical staff who have to work with the system on a daily basis, right from the beginning. While management must approve the implementation, partially also due to patient data privacy, medical staff must be willing to be part of the transition.

Abugabah et al (2020) additionally recommend combining Machine Learning techniques with RFID technology to use the huge amount of data to “provide a personalized diagnosis and care for patients depending upon their medical history, age, gender, drug vulnerability”. This is a crucial step to identify patterns so that different care pathways can be developed for different patient groups. For that matter, we have decided to use process mining as a tool, which we will discuss in detail later. In the next step, we integrate the collected data with the health information system in which the activities and patient data are recorded.

4.3 Data collection

Categorizing patients by diseases is a fundamental practice in healthcare with profound implications. This process, which involves classifying individuals based on their specific medical conditions, is crucial for various reasons. It empowers healthcare institutions to allocate resources efficiently, tailoring services to meet the unique needs of different patient categories. Therefore, ensuring accurate diagnosis and personalized treatment and allowing for tailored healthcare plans to each patient's unique needs, thus fostering a patient-centered approach that enhances overall satisfaction engagement.

As a foundational element for optimizing healthcare workflows, patient categorization identifies common patterns within each category, streamlining processes and improving operational efficiency. Moreover, it facilitates a careful cost analysis, providing accurate insights into the financial implications of each patient group. This data would allow healthcare providers to assess their performance and identify areas for improvement. In terms of cost-effectiveness, tailoring treatment to a patient's specific needs can lead to the avoidance of unnecessary tests, treatments, and hospitalizations. This not only benefits individual patients but also reduces healthcare costs for both individuals and society. The categorization seems to be indispensable for strategic financial planning and cost-containment initiatives proven to be crucial for healthcare efficiency.

Genetic factors and family medical histories are critical components, acknowledging the influence of inherited traits on disease predisposition. A patient's medical history, encompassing past illnesses, surgeries, and treatments, contributes to a complete understanding of their health profile. Lifestyle factors, including diet, exercise, and exposure to environmental elements, add depth to the categorization process. Also, the process contributes to epidemiology and public health by providing insights into disease prevalence and patterns.

An interviewee mentioned that the patient data needed is very specific to the disease. In general, gathering data on age, gender, severity of disease is important. The MD from UZ Gent confirmed this information and added that they also observed that there is a difference between being a new patient or old patient regarding the duration of an activity, e.g. new patients require significantly more time for a consultation. Hence, this would also be important data to include. They proposed that apart from the generic data, they would collect the rest of the data depending on the specific diseases. The interviewee said that as a starting point, they would aim for more generic pathways. In their project, the data related to the patient came from the patient files, whereas the financial specific information came from the financial department of the hospital.

The process of classifying patients in an automated TDABC system for healthcare is fundamental, emphasizing the need for robust data gathering. Basic patient demographics, such as age, gender, and medical history, as well as clinical data—specific information about a patient's health, diagnosis, course of treatment, and results—must be gathered before any patient categorization can take place. All this data can be collected from the hospital software, with the patient's consent.

The bracelet will automatically collect activity data, this includes the time and resources allocated to each activity. The time data is essential for TDABC accurate cost calculations. There should be a cost matrix built within each healthcare institution, including direct and indirect costs associated with patient care, comprising labor costs, equipment costs, and overhead expenses.

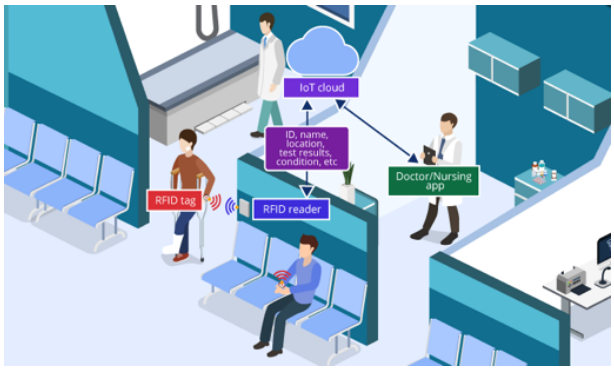

Figure 1: Smart Patient Tracking with RFID. Source by Shiklo, 2018.

As delineated in the preceding sections, the outcome of this process is the generation of an all-inclusive patient pathway. The costs can then be thoroughly examined, considering the views of individual patients as well as the different classification factors that were methodically gathered.

4.4 Interoperability Standards

Interoperability can be defined broadly as the capacity of various software applications and information and communications technology systems to communicate, and exchange data in an accurate, efficient, and consistent manner, and make use of the shared data (Iroju, O. et al, 2013). In the context of healthcare, interoperability refers to the capacity of two or more eHealth systems to use and exchange information that can be understood by humans as well as by computers (eHealth Governance Initiative, 2012). Efficient information exchange among patients, payers, and providers is essential to the delivery of healthcare. Data flow patterns pertaining to millions of individuals across a large geographic area are involved in this communication.

Three main factors define interoperability in eHealth. Firstly, legal interoperability refers to the wider framework of laws, regulations, guidelines, and collaboration agreements that are required to enable smooth information sharing amongst various organizations, nations, and regions. It creates the legal foundation for cooperative information sharing. Semantic

interoperability, on the other hand, guarantees that the information exchanged has a clear and precise meaning that can be understood by any system, service, or user. This part focuses on removing uncertainty in the data's interpretation and developing a common understanding of it. Finally, the capacity of information and communication technology applications to accept data from one another and carry out a specific task without the need for extra operator intervention is known as technical interoperability. It highlights how different systems can be seamlessly integrated to carry out tasks efficiently. Reaching eHealth interoperability for a particular use case requires careful consideration of each of these factors. It entails putting in place uniform technical and semantic standards to lay the groundwork for efficient and standardized information sharing throughout the eHealth ecosystem.

Back in 2012, eHealth Governance was already mentioning the diverse benefits of semantic and technical interoperability. Technical interoperability enables access to, and correct interpretation of, medical information by different healthcare providers and medical disciplines as well as in different countries, regions, and nations. Furthermore, it ensures that, as patients access care from a variety of healthcare providers, there is a seamless flow of a patient's medical history. Enhanced quality of care Semantic and technical interoperability assures a common understanding of medical information and subsequently leads to a reduction in medical and prescription errors.

Healthcare interoperability presents several possible advantages for institutions. The smooth integration throughout the entire healthcare system is one of its main benefits. By facilitating data communication, workflows are streamlined, and medical device integration is supported. Organizational efficiency is increased when different components, such as medical devices, laboratories, and operations, can easily exchange data.

Moreover, by allowing internal systems to communicate, interoperability enhances administrative and business processes. Time-consuming processes, like processing patient intake data, are eliminated by this integration. Information flows smoothly, reducing duplication and human error, when appointment scheduling, patient portals, medical billing software, and electronic medical records (EMR) are integrated. Furthermore, interoperability encompasses materials management, simplifying the process of upgrading medical equipment and swapping out consumables.

The streamlining of reporting procedures is an additional important advantage. Various stakeholders in the healthcare ecosystem depend on common terminology, measurements, and codes. By optimizing the infrastructure, interoperability guarantees that the healthcare system functions effectively while adhering to legal requirements for patient privacy and security. An effective ecosystem like this is essential to the successful implementation of interoperability.

The guidelines, protocols, and specifications known as interoperability standards and frameworks specify how various healthcare systems, applications, and devices should exchange data and communicate with one another in an efficient and smooth manner (Apaana, 2023).

Fast Healthcare Interoperability Resources

The Fast Healthcare Interoperability Resources (FHIR) is an emerging interoperability framework that offers a contemporary, standardized framework for information sharing across various healthcare systems, thereby representing a revolutionary approach to healthcare data exchange. FHIR is intended to provide a more adaptable, scalable, and developer-friendly solution by addressing the shortcomings of conventional healthcare interoperability standards, thereby fostering interoperability among various systems and stakeholders. Fundamentally, FHIR is composed of a collection of interchangeable parts called resources, each of which stands for a distinct subset of medical data, such as diagnoses, prescriptions, or patients.

FHIR adopts an architecture that is based on RESTful APIs, utilized for the interchange and representation of health data kept by the HL7 standards development organization (FHIR Fact Sheets), which makes it ideal for the web and simple to integrate with other contemporary technologies. This design decision facilitates easy access to and sharing of data, which helps disparate systems work together. Data representation and transmission are made simpler and more effective by using common data formats, such as XML and JSON.

The emphasis that FHIR places on simplicity and ease of implementation is one of its unique characteristics. A more intuitive understanding of healthcare data is encouraged by FHIR's resource-oriented approach, in contrast to earlier standards that might have been complicated and inflexible. This consistency in data representation across various implementations is ensured using standardized terminologies and coding systems, which further contribute to its simplicity.

FHIR is intended to be extensible, allowing organizations to tailor and extend the standard to their specific requirements. This flexibility is essential in the dynamic and quickly changing healthcare environment, where new requirements and data elements appear regularly. The support of major healthcare organizations and regulatory bodies for FHIR is driving its global adoption. “FHIR has already gained widespread acceptance and there is rapidly growing adoption globally by governments, businesses and healthcare delivery organizations.” (Agnew, 2023). A more integrated and effective healthcare ecosystem could be created as FHIR gains more traction and is widely adopted.

Within the healthcare ecosystem, FHIR is essential to achieving standardized and interoperable data exchange. We ensure a comprehensive view of patient-related activities and costs by establishing a strong foundation for consistent and compatible data by seamlessly integrating FHIR into our TDABC solution. One essential feature that FHIR supports is real-time data

exchange, which makes it possible for accurate and timely information to flow. We guarantee access to current data by incorporating FHIR into our TDABC solution. Accurate cost calculations and well-informed decision-making are essential in the ever-changing healthcare landscape.

5. Business Model

In the dynamic world of healthcare innovation, our solution emerges as an automated comprehensive end-to-end approach to more efficiently track patient costs within healthcare institutions. Having in it the integration of the VBHC and TDABC methodologies with the technologies of RFID and Process Mining, we have it named "WristFlow Navigator". This cohesive synergy of technologies aligns with our key activities and forms our competitive advantage.

To position our solution in the market, a business model has been outlined, covering each of its constituents and setting their strategic relevance. It is set to reshape the operational work of healthcare institutions.

As mentioned, as its core, our proposition represents a comprehensive solution designed to optimize resource allocation and improve operational efficiency through the use of TDABC and VBHC frameworks, being then specifically targeted at healthcare institutions and insurance companies. Positioned as pioneers in comprehensive innovation, our brand strategy focuses on data integration, cost-effectiveness, and tangible benefits for institutions. Through targeted marketing strategies, scoped on digital platforms and industry engagement, we aim to position ourselves as trusted partners in advancing healthcare technology. Emphasis is further given to the legal topics. Data security and patient privacy are extremely important. Following with the geographical regulatory environment is a topic that cannot be overlooked.

To sustain our operations, diverse revenue streams were mapped, including setup fees, subscription models, volume-based pricing, customization charges, and data analytics consulting services. The diversified approach was thought to ensure sustainable growth while addressing the diverse needs of our market segments. On the costs side, the structure includes the technology infrastructure, software development, personnel salaries, marketing, administrative, regulatory compliance, risk mitigation, and flexibility needs. We aim to guarantee financial sustainability.

5.1 Value Proposition

In today's healthcare and innovation landscapes, our proposition is bold yet practical, a testament to transformative innovation set to redefine the landscape of patient cost tracking. At the heart of our mission lies a comprehensive solution designed to advance healthcare operations with a higher precision and efficiency.

Our mission revolves around redefining cost management in healthcare institutions by integrating TDABC principles, harmonized with the core values of VBHC. The solution revolves around the disposition of wristbands powered by RFID technology that meticulously track and record each patient's entire care trajectory. By capturing real-time data on the duration spent in each care activity, a level of precision and granularity is provided to cost analysis, a crucial aspect in optimizing resource allocation and operational efficiency.

The journey does not end with data collection; it begins there. Leveraging process mining techniques, we uncover reflective insights from that repository of patient-centric data. Through the incorporation of using RFID technologies and process mining, our approach was aimed to surpass the limits of traditional patient tracking systems and provide a more comprehensive evaluation of costs, resource utilization pattern. This data analysis forms the foundation for

informed decision-making aimed at optimizing costs while enhancing the quality and effectiveness of care delivery.

We empower healthcare institutions with a dynamic toolkit to ultimately analyze, strategize, and execute. By delivering comprehensive, actionable insights, they are further equipped with transparency into financial plans, allowing for a more-informed pricing, negotiating of contracts, and allocating of budgets. We target health professionals, administrators, and decision-makers, offering them a sophisticated approach to cost management that enhances both agility to adapt, operational effectiveness and financial sustainability.

5.2 Target Segments

Our offering emerges as a pivotal solution aimed at systematically optimising the operational activities and associated costs within healthcare institutions, using the TDABC and VBHC frameworks. Specifically tailored to the complexities of the healthcare industry, our primary target segment are healthcare institutions seeking a sophisticated approach to cost management. These institutions stand to achieve unprecedented levels of efficiency and precision in their resource allocation, enhancing both operational effectiveness and financial sustainability.

Our solution facilitates a clear understanding and management of costs, allowing for more precise cost allocation to activities and processes as well as a better comprehension of resource consumption and cost drivers. This transparency proves to be crucial for healthcare institutions, as it fosters more informed discussions and strategic decision-making. Additionally, our product enables institutions to elaborate more realistic financial projections, facilitating appropriate pricing, negotiating contracts, and allocating budgets effectively.

The insights provided by our solution are essential for process improvement initiatives, empowering healthcare institutions to standardize and streamline workflows, ultimately

reducing costs and elevating overall service quality. Regular analysis of costs encourages ongoing evaluation and adjustment of processes, ensuring that the institution remains adaptable and responsive to the evolving dynamics of the healthcare industry.

Furthermore, our solution extends its value proposition to include insurance companies operating within the healthcare ecosystem. Given that our product covers a comprehensive spectrum of costs associated with patient care, insurance companies stand to advantage with significant benefits from the transparency and granularity embedded in our automated TDABC-based solution. This includes not only direct medical expenditures but also indirect operational expenses, offering insurers a more accurate and thorough understanding of their exposure.

The approach on insurance companies is to provide access to the useful data that the product extracts, rather than selling the product itself. We offer a service that enables businesses to use and examine the insightful data produced by our automated TDABC-based solution in place of a typical product sale. This distinction demonstrates our commitment to providing strategic value and actionable intelligence through the application of our technology, in line with a data-centric model as opposed to a product-centric one.

In healthcare sector, insurance companies continue to place a high priority on cost control. This strategic focus results from a confluence of interrelated factors that together shape financial stability, competitiveness, and sustainability. The financial viability of insurance companies is closely related to efficient cost management. In a sector where healthcare costs are constantly rising, efficient management is critical to reducing financial stress and maintaining insurers' long-term viability. Strong cost control strategies give insurers a distinct advantage in a competitive market where they must navigate complexities to achieve cost-effectiveness.

Strategic cost management serves as a form of risk management, protecting insurers from financial vulnerabilities and improving overall resilience. Moreover, regulatory frameworks

frequently require insurance providers to actively demonstrate efforts to reduce healthcare costs. As our product maps every process within healthcare institutions and associates it with a cost then insurers can provide comprehensive coverage at a justifiable price, emphasizing the perceived value of insurance plans in relation to incurred expenses.

Our product's distinct strength lies in its ability to handle the complexity of healthcare cost systems, providing an overarching view that extends beyond traditional cost management methodologies. This positions us as a strategic partner for both healthcare institutions and insurance companies, allowing for more informed decision-making, improved resource allocation, and more financial accountability. Through ongoing support, customization, and a keen understanding of the dynamic healthcare landscape, we aim to empower our clients with the tools they need to navigate the evolving challenges of the healthcare industry effectively.

5.3 Channels and Customer Relationships

Our business model is strategically aligned to deliver sustainable value, positioning healthcare institutions and insurance companies at the vanguard of a cost-conscious and patient-centric paradigm. The journey starts with the realization that the healthcare sector demands not only a thorough awareness of its specific challenges but also a tailored approach that speaks directly to the needs of healthcare institutions and insurance companies.

A comprehensive engagement plan must be established to reach and interact with our target customers. This plan should include a dedicated and skilled team with a profound understanding of the healthcare sector which would directly establish one-on-one relationships with decision-makers within healthcare institutions and insurance companies. Attendance and actively participate in prominent healthcare conferences and industry events should also be included in this plan. These venues provide invaluable opportunities to showcase your product, engage with industry leaders, and gain first-hand insights into the challenges faced by healthcare institutions

and insurance companies. Additionally, we could demonstrate our expertise by publishing articles and case studies that address pertinent issues within the healthcare and insurance sectors, emphasizing how our product aligns with industry trends and provides innovative and effective healthcare cost management.

Offering tailored educational workshops and training programs for healthcare professionals and insurance company staff about how the product works by providing detailed insights into the functionalities and how our partners can benefit from using it, could also be an interesting measure to engage and attract our target customers. These sessions should be interactive, addressing specific concerns and showcasing the practical application of your solution in real-world scenarios. Collaborate on initiatives that contribute to industry advancement, solidifying your position as a key player committed to the betterment of the sector.

Establish a routine communication channel and implement mechanisms, allowing for continuous feedback, through newsletters and regular updates. Share industry insights, product enhancements, and success stories with personalized customer reports and insights. Maintaining an open line of communication to keep healthcare institutions and insurance companies informed about the ongoing benefits and developments related to our solution and to understand their experiences with our solution and help us to identify areas for improvement.

The success of WristFlow Navigator depends on cultivating a close relationship with our target customers. This calls for extensive interaction with both the administrative group and the employees who work directly with healthcare facilities on a daily basis. We make sure that frontline employees' needs, challenges, and perspectives are fully understood by involving them, as they will be directly interacting with our solution.

Our strategy places a strong emphasis on open communication about the observable advantages that our solution offers to their day-to-day operations. It's critical to explain how our product

offers insightful data that enables employees to be more productive in their jobs. These insights have the potential to improve decision-making procedures, expedite workflows, and increase overall operational effectiveness. Our goal is to instil a sense of ownership and enthusiasm in the staff by showcasing the positive effects of our solution on their daily tasks. This will facilitate the solution's successful adoption and integration into their workflows.

The secret to successfully managing the healthcare and insurance professional environment is to take an exhaustive and flexible approach that combines industry knowledge, individualised engagement, and a dedication to meeting the specific needs of our target customers.

5.4 Key Activities

At the heart of our proposed solution lies a crated framework mentioning the key activities. These activities form the pillar of our approach towards improving patient cost tracking accuracy and operational efficiency within healthcare institutions and will be followingly presented. Details on how they will strategically and operationally deliver value to our identified costumers will additionally be outlined. The framework will not only entail technological implementation, but also staff readiness. We present the crucial activities involved in hardware installation, software application, and preparing all crucial staff through specialized workshops.

1. Patient Journey Mapping: Our initiative begins with an in-depth examination of patient journey. Through detailed mapping, we aim to chart every point within the healthcare system—initiating from admission, progressing through treatment, to eventual discharge. The ultimate purpose is to identify the incurred costs, possible inefficiencies and streamlining patient flows. Such process will be possible through the use of the mentioned RFID bracelets/ wristbands.

2. Staff Preparation Workshops and Training Sessions: Recognizing the dangerous potential resistance that healthcare staff may have towards the requirements of our proposed solution, it is fundamental to proactively prepare, educate, and empower these professionals. Without them on board, no insights will be collected. To achieve this, our strategy is to have specialized workshops and training sessions designed to equip the healthcare force with a comprehensive understanding and proficient utilization of the implemented systems. The primary goal of such initiatives is to cultivate a skilled workforce capable of leveraging these technological advancements while fostering a culture of continuous improvement.

3. RFID Integration and Infrastructure Setup: Deploying RFID technology is central to our strategy. For that, a designated team will orchestrate the deployment of RFID hardware components, taking care of the installation and configuration of RFID wristbands, readers, gateways and supporting infrastructure across designated areas within the healthcare facility. Each installation process will undergo quality checks to ensure a complete coverage, connectivity, and functionality.

4. Software Application and Integration (data harmonization through process mining): Following the hardware setup, a team of the corresponded experts will then focus on application and integration of software systems. Such process involves coordinating disparate data streams, transforming them into coherent, structured insights, conducted in accordance with industry´s legal guidelines. Ensuring robustness and compatibility across existing systems is crucial to then extract actionable conclusions, facilitating informed decision-making and process optimization.

5. Workflow Optimization and Operational Refinement: Considering the data insights, a team of professionals will elaborate workflow optimizations. This phase will be more concentrated on identified costs tracking, fine-tuning operational processes, optimizing

resource allocation, and synchronizing workflows. The intended outcome is to provide an operational blueprint that enhances efficiency and reduces obstructions.

6. Ongoing Support and Consultation: Our services will be extended beyond the initial implementation, with the provision of continuous support and consultation. Regular performance assessments will be conducted to ensure system effectiveness and operational efficiency on the business as usual activities. Simultaneously, ongoing assistance will be provided to guarantee that staff has access to support resources and guidance to navigate any operational challenges that may arise. These ongoing evaluations and consultative approach steer our strategy towards a smooth transition and effective utilization of the implemented systems.

5.5 Revenue Stream

In the ever-evolving landscape and ultra-competitive of healthcare technology, sustainable revenue streams are vital components that reinforce the success and viability of innovative solutions. Focused on the integration of RFID-based patient tracking and process mining, this section delineates a strategic roadmap for revenue generation tuned to the TDABC and VBHC frameworks. Our analysis navigates through a range of models, namely tiered subscriptions, volume-based pricing structures, customization fees, training packages, data analytics services, and strategic partnerships. Each stream serves a different purpose and is strategically considered to address distinct customer segments. Thus, it is our opinion that taking usage of a combination of these streams might be more effective to ensure a diverse income flow and cater to different market segments, while ensuring scalability, value delivery, and sustainable growth in an era driven by digital transformation.

The considered revenue streams are:

Start by charging for a one-time sale of the initial setup, hardware installations, and software licensing. The pricing will be defined by the scope of the hardware installation (how many wristbands, readers, gateways, and other components) all of these will depend on the institutions quantity plan and of course the size it entails), and on the software modules purchased. By doing so, there will be an immediate revenue influx from the implementation phase, covering initial costs.

Simultaneously, we would follow the tiered subscription-based models' strategy. We intend to sell subscription plans for ongoing support, maintenance, and updates of the implemented systems, based on the scale and needs of healthcare institutions, and offering service levels or functionalities offered. The payments would be on a monthly, quarterly or annual basis. This strategy is predicted to bring recurring revenues, ensuring continuous customer support and system enhancements. It would also be a way to guaranty scalable pricing that accommodates institutions of different sizes, while ensuring value alignment with their requirements. That is, a way of ensuring scalability without compromising value.

Additionally, we believe in a differential pricing approach, charging prices based on project sizes to leverage cost reduction advantages for larger-scale implementations. This principle guides our adoption of a volume-based pricing strategy, meaning that scaled pricing or discounts will be proposed to larger healthcare facilities based on their usage or facility size. Ideally, such strategic thinking will encourage a broader adoption among larger institutions, while fostering widespread implementation of our solutions through enticing and scalable pricing models.

Our intention is also to offer customers the opportunity for tailored solutions beyond the offered standard proposal. For that they will be charged customization fees. Such approach will allow us to provide specialized customization or integration services that go beyond standard

offerings and that cater to diverse institutional requirements. By embracing this flexible approach to address specific customer needs, we ensure a more precise alignment of our solutions to meet the unique requirements of each institution. This initiative not only enhances customer satisfaction and fosters stronger partnerships but also brings in additional revenue, creating a mutually beneficial arrangement for both parties.

Complementally, advanced data analytics services that transcend standard the system functionalities will be provided. These encompass in-depth data analysis reports or tailored analytics solutions, charged for a fee.

It goes without saying that integrating our proposal technological solution is inherently complex. In the post-implementation phase, during the “business as usual” routine operations, it is expected that various inquiries and complexities will emerge, requiring our deemed attention and support. For that, specific consultation and training/ support packages will also be part of our services’ portfolio. These premium packages include specialized on-site consultation, workshops, and staff instruction sessions, offered for a fee. Following the same line as before, such strategy aims to not only boost our revenue, but also to guarantee continual support, elevating customer satisfaction through sustained assistance.

Implementing a licensing model serves as an additional revenue stream, offering licensing options for specific features, advanced modules, or supplementary functionalities at a cost. Although coming up with some challenges such as imitation concerns and heightened exposure of Intellectual Property, such strategy presents a significant opportunity for generating passive income and exploiting new market chances.

5.6 Cost Structure

Knowing how revenues will be generated comes as crucial to any business, and so does the cost structure. This section details a breakdown of the anticipated expenses across various categories, examining both direct and indirect costs. From hardware and software investments to personnel salaries, training, and compliance considerations, this section details the financial aspects for the successful implementation and sustenance of our innovative solution.

5.6.1 Direct Costs

Comprising our business proposal, one would notably think of the hardware and software expenses in order to make in properly running. And so, for the technology infrastructure, costs involving the procurement and maintenance of RFID components – such the wristband bracelets, readers, gateways, and requisite software systems – must to be accounted for.

The use of RFID wristbands has become widespread, serving a range of purposes such events accessories, payment methods, tracking devices). As a result, their costs are typically not exorbitant, ranging approximately between cents to €10 per unit. This pricing fluctuates based on several factors such as functionality, quality, and specific vendor offering. Also varying based on bulk purchase discounts, customization options, and additional features like durability, waterproofing, or specific integrations required for given applications. Specifically tailored for the healthcare sector, *Zebra Technologies* stands out as a strong supplier of RFID wristbands. Alongside, companies like *Impinj*, *Alien Technology*, *Smartrac, Avery Dennison* and *GlobeRanger* have also gathered recognition for providing similar products designed for a multitude of industries. Concerning, RFID readers costs' surround the zone of $200 to $2000, depending on the features in the device. Server infrastructure costs may vary widely based on scalability needs but estimated between $5,000 to $20,000 or more for initial setup. It is crucial

to invest in scalable, cloud-based infrastructure to handle increased data loads and user demands.

Needless to say, that all costs related to software development should not go unnoticed. Such costs vary significantly based on the complexity of the system, the level of customization required, the number of features, the technology stack used, the development team's expertise, and ongoing maintenance needs. Initially, the costs involve the creation of the core system, emphasizing database architecture, user interface, and basic functionalities that facilitate RFID data management and patient movement tracking. Furthermore, customizing the software to integrate with existing hospital systems and creating analytics reports as per client demands constitutes another significant expense. Ongoing costs include continuous software improvements, updates, bug fixes, and provision of technical support, ensuring optimal system performance and user assistance. While the actual figures vary based on project intricacies, industry estimates suggest software development costs can range from tens of thousands to hundreds of thousands of dollars.

Hand-in-hand with the core expenses just mentioned, lie the vital personnel costs. This encompasses all salaries and wages allocated to the diverse range of professionals engaged in the development, implementation, consultation, training, and ongoing support for our solution. These include experts in TDABC and VVBHC, specialists proficient in RFID technology and process mining, project managers, software developers, data analysts, cloud architects, marketers, and more. Notably, the scarcity of professionals specializing in TDABC, VHC, RFID, or process mining means considerable investments in salaries to attract and retain talent possessing such expertise. It goes without saying that salaries will vary according to the role of player and the contributive part the person has to the final solution.

In terms of capital expenditure (CAPEX) planning, one could predispose the allocation of funds for technology upgrades in order to ensure perpetual enhancements, thereby aiming at making our solution's competitive and in alignment with industry benchmarks. Concurrently, budgetary resources should be dedicated to ongoing research and development (R&D) initiatives to proactively tackle emerging challenges while seizing novel opportunities in the healthcare technology landscape. In the dynamic world of technology, rapid change is a constant. Failing to invest in continuous innovation risks could mean missing out on crucial breaks.

5.6.2 Indirect Costs

Complementary, expected spending in Marketing and Sales comes as fundamental. The aim is not solely focused on attracting new clientele but also solidify our position as a frontrunner in delivering innovative comprehensive solutions in the healthcare landscape. A way of ensuring successful market penetration and a sustainable growth.

Administrative costs are also anticipated. These encompass various essential aspects, including administrative staffing, office infrastructure, insurance, utilities and general operational expenses necessary to sustain day-to-day functions.

Regulatory compliance matters are also anticipated on our costs' structure framework. Given the sensitive and highly regulated nature of healthcare data and patient information, adherence to stringent regulatory standards such as HIPAA and GDPR is fundamental investing towards comprehensive regulatory compliance, not only mitigates legal risks but also upholds the trust and confidence of healthcare institutions in our solution's capability to handle patient data ethically and securely.

Irrevocably, envisaging costs regarding risk mitigation and flexibility is indispensable to fortify our operational resilience. Having incorporated contingency plans strategies serve as a shield

against unforeseen challenges or financial risks that may arise during our solution deployment. It is of clear importance to be prepared to navigate any operational disruptions and ensuring uninterrupted service delivery and maintaining the trust of healthcare stakeholders. Furthermore, retaining flexibility in budgeting stands as a cornerstone, allowing agile adaptation to fluctuating market dynamics and unexpected expenses.

As an additional costs overview, one can consider the difference between fixed and variable costs. In our solution's business framework, Fixed expenses encompass administrative costs, software development, and infrastructure maintenance. Conversely, variable costs entail consultation/training fees, project-specific personnel expenses, and marketing expenditures.

5.7 Key Resources

The success of any innovative solution is intricately tied to the robustness and effectiveness of its foundational resources. Being our proposed solution comprehensively focused on using RFID technologies and process mining to do a better cost allocation according to the TDABC principles in a VBHC landscape, there is an array of resources required that smoothly work together. The following section delves into a comprehensive exploration of those key resources that underpin our proposed solution.

Firstly, one would have to highlight the expertise on the methodologies of TDABC and VBHC. The first stand as a foundation to our cost optimization strategy, enabling meticulous cost allocation and monitoring across various healthcare activities. This approach will enable to more precisely assess resource utilization, identify inefficiencies, and streamline processes. At the same time, the focus on VBHC principles guides the strategic alignment of our solution with value-driven care models, prioritizing patient outcomes and care quality.

Followingly, at the core of our solution lies RFID technology, comprising RFID wristbands, readers, and associated infrastructure. Beyond its primary function in patient identification and tracking within healthcare facilities, our expertise extends to leveraging this technology to integrate TDABC methodologies. This innovative approach allows for a more precise cost allocation and monitoring of activities, contributing to optimized resource utilization and cost efficiency.

Complementary, we will take upon the utilization of process mining software to comprehensively analyze and optimize healthcare workflows. By applying TDABC principles into process mining, data insights will be holistically extracted from operational data. Overall, this integration empowers healthcare institutions to streamline processes, identify cost drivers, and prioritize value-adding activities within patient care pathways.

To develop this comprehensive approach, we rely on skilled professionals that excel in different areas, such RFID technology, process mining software, data analytics, software development, cloud architecture, healthcare operations, and the dominate the nuances of TDABC and VBHC methodologies.

Ultimately, the synergy among these resources amplifies value delivery within the healthcare ecosystem. Their collective roles and complementary activities align with our key activities. While these resources represent innovative developments, their standalone contributions do not singularly drive healthcare advancement. It is the comprehensive nature of our solution that truly sets us apart, working as the pillar serving as of our competitive advantage.

5.8 Technology and Innovation

We set out on a strategic path to improve healthcare operations, give patient care top priority, and offer insightful data for ongoing development as we put our all-inclusive solution into practice. A thorough mapping of the healthcare facility is the first step in the process, which is essential to comprehending the nuances of each room's activities and determining their interdependencies.

Subsequently, RFID sensors are installed on each door, allowing for real-time patient and staff tracking. In addition to improving identification efficiency, the issuance of RFID wristbands guarantees smooth tracking across the hospital. Fast Healthcare Interoperability Resources (FHIR) standards are used to ensure compatibility and coherence in data exchange, allowing us to seamlessly integrate this abundance of data into the hospital's current software.

Our solution's central component is the FHIR database, which provides safe, uniform storage for medical data. This structured data serves as the basis for further analysis, which provides insights into patient pathways, resource utilization, and workflow efficiency. This is where the in-house process mining tools really shine, providing a deeper understanding of patterns, bottlenecks, and opportunities for optimization.

Our efforts have culminated in the creation of insights that can be put into practice through data analysis and visualization. Administrators are able to make well-informed decisions about the allocation of resources, process enhancement, and overall operational efficiency because they have a comprehensive understanding of the healthcare processes.

Our solution is flexible enough to accommodate the institution's expanding needs and is designed to be both scalable and adaptable. Healthcare management is now more unified and interoperable thanks to the combination of RFID technology, FHIR standards, and process

mining tools. The end product is a reliable system that not only streamlines existing processes but also establishes the foundation for upcoming technological developments in the healthcare industry.

Our approach will transform healthcare administration by utilizing cutting-edge technology and innovation. We establish a smooth and interconnected ecosystem within healthcare facilities by combining RFID wristbands, readers, Fast Healthcare Interoperability Resources (FHIR) standards, and process mining tools. By ensuring real-time tracking and identification of patients and staff, RFID technology is used, improving overall efficiency and security. Compatibility and coherence throughout the healthcare system are ensured by FHIR standards, which allow standardized and secure data exchange. Administrators can now see workflows, resource usage, and patient pathways like never before thanks to the use of process mining tools. In addition to streamlining present healthcare procedures, this well-balanced fusion of innovation and technology opens the door for ongoing improvements in patient care and organizational effectiveness.

The following diagram serves as an illustrative example of how our technologies are seamlessly integrated and interconnected. Every element complements the others to create a seamless and all-encompassing solution. This networked system guarantees a unified approach to healthcare management, optimizes efficiency, and improves data flow.

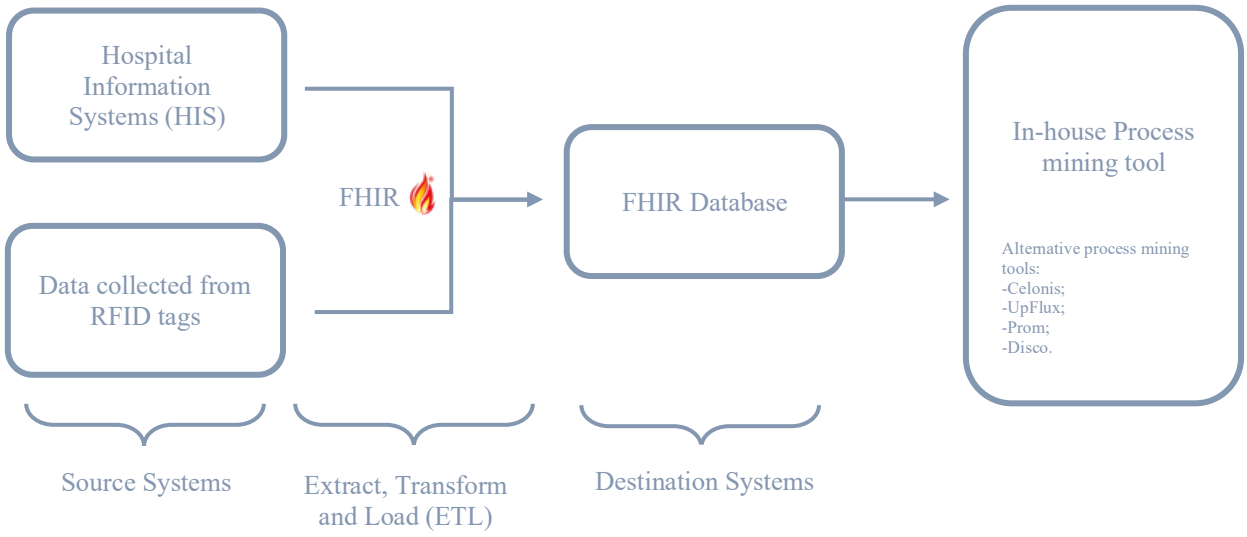

Figure 3: Data Flow. Source by Anonymous FHIR expert.

5.9 Brand and Marketing Strategy

The brand strategy and marketing approach are integral components in shaping how our solution is perceived in the healthcare technology market. Among major priorities comes crafting a compelling brand narrative, defining key brand elements, and strategizing impactful marketing tactics to successfully communicate our value proposition. This section expands onto the devised strategy and marketing initiatives to establish a distinctive brand identity and effectively promote our solution to our defined targets - hospitals and insurance companies.

5.9.1 Brand strategy

Our brand strategy revolves around positioning our solution as a center of comprehensive innovation in the healthcare technology landscape. The core pillars of our brand include reliability, technological expertise, comprehensive embrace and a dedicated commitment to enhancing patient care. To better launch a distinct brand identity, it was given emphasizes to brand positioning, messaging, voice and lastly, visual identity.

As mentioned, considering recent market trends and available solutions, one could consider that the healthcare industry is severely lacking a comprehensive solution that efficiently interconnects data from patient tracking to better reflect in cost allocation and resource optimization. Subsequently, we are strongly investing in our solution's comprehensive element to set us apart. More specifically speaking, our brand will be positioned as an innovative, comprehensive, and indispensable tool for healthcare institutions striving for operational excellence and ultimately superior patient outcomes. Such position statement serves to highlight the transformative impact and competitive advantage that our solution offers.

To communicate such value proposition effectively, we intend to take usage of a clear and compelling brand slogan, that is aimed to convey the ease of integration, cost-efficiency, and the tangible benefits it brings to healthcare facilities. The slogan is: "*Empowering Value, Tracking Excellence*". This message is directly targeted to our focus audience, such healthcare decision-makers in healthcare organizations and insurers.

As briefly mentioned previously, implementing our solution involves integrating the continuous scan of a patient's RFID wristband throughout their care journey. Additional non-practical tasks will be asked to be performed by healthcare staff, who will unavoidably raise some concerns and likely resistance. Notwithstanding, our solution will bring more benefits than the additional effort it requires. Yet, not everyone may readily recognize these advantages, especially when confronted with added tasks. This is why our initial brand messaging will be also strategically directed at healthcare institution decision-makers, who possess a comprehensive understanding of their organization's managerial landscape and resources utilization. Those are the ones who really need to hear what we have to say and decide upon that. Subsequently, all stakeholders involved will be communicated to, ensuring a comprehensive understanding and alignment across the board.

Alongside our brand messaging comes the visual look to what it will be associated. A visually appealing and professional brand image will be cultivated through a cohesive visual identity, including a memorable logo, color palette, typography, and design elements. This consistent visual representation will reinforce brand recognition and credibility. Insert logo, slogan, and poster. At the same time, a consistent brand voice that reflects our values, commitment to innovation, and dedication to healthcare improvement will be established across all communication channels.

5.9.2 Marketing strategy

Our marketing strategy embodies a multifaceted approach, designed to vibrate with and engage our target audience across diverse channels and touchpoints. Passing through leveraging digital platforms to spread our innovations, to implementing content marketing initiatives and actively participating in industry specific events, our marketing endeavors are crafted to deliver a cohesive and compelling narrative about our solution's transformative potential. The ultimate goal is to drive adoption and solidify our position as a trusted partner in advancing healthcare technology.

In today's interconnected global society, embracing digital platforms isn't just a necessity; it's a strategic imperative. Through digital marketing, we'll harness the power of various online avenues, including social media, content marketing, search engine optimization (SEO), and targeted online advertising campaigns. Our aim is to amplify our online presence and visibility by offering thought-provoking and informative valuable content, educational resources, and compelling case studies, while establishing our authority and relevance within the healthcare technology landscape.

Furthermore, it is our intention to have an active participation in relevant industry events, conferences, and seminars. This will enable us to showcase our solution, network with industry

professionals, and demonstrate our expertise. Not to mention the likelihood of engaging directly with potential clients. This approach will foster relationships and generate leads within the healthcare sector. Taking part in general entrepreneurial seminars (like Web Summit) could also provide some beneficial head points. On the one hand, these seminars often provide a wealth of knowledge on general business strategies, innovative technologies, and marketing techniques that could be applied, albeit indirectly, to our healthcare-specific solution; on the other, such events offer exposure to a wider audience, allowing for cross-pollination of ideas and learning from different perspectives.

In a more inventive spectrum, we are considering the prospect of hosting/sponsoring hackathons or innovation challenges. Such would be aimed at inviting developers, healthcare professionals, and technology enthusiasts to ideate or build solutions that integrate with our platform, fostering innovation and community engagement.

5.10 Legal and Regulatory Environment

A deep comprehension of legal and privacy frameworks is essential in the field of healthcare data management in order to guarantee ethical practices and uphold stakeholders trust, such as patients, insurance companies and healthcare institutions.

5.10.1 GDPR Compliance

General Data Protection Regulation (GDPR) compliance becomes essential to guaranteeing the moral and legal handling of personal data in the context of our solution, which includes the gathering and administration of sensitive patient data. It creates a strict set of rules and regulations that control how personal data is processed, stored, and shared, promoting an open and responsible data management ecosystem while assuring that personal sensitive information is handled carefully and in compliance with all legal requirements. Adherence to the GDPR is

imperative for healthcare establishments functioning within the European Union or managing the data of EU citizens. GDPR (Regulation (EU) 2016/679) is a legislative instrument that implies, on the one hand, a clear reinforcement of the rights of data subjects and, on the other hand, an extension of the organisations' obligations in terms of privacy (SPMS, 2017).

The GDPR's focus on purpose limitation and data minimization is in perfect harmony with our end-to-end solution's guiding principles. Our solution reduces the risk of needless data exposure and increases data management efficiency by closely following these principles, which guarantee that only pertinent and necessary data is processed for legal purposes.

Our solution's integration with FHIR is intrinsically related to GDPR compliance, demonstrating our steadfast dedication to preserving patient privacy and data security. In order to assure that patient information is handled morally, legally, and openly, our solution complies with the strict guidelines set forth by GDPR for the processing, sharing, and storage of personal data. We prioritise data minimization, purpose limitation, and individual rights by integrating GDPR principles into WristFlow Navigator architecture, offering a strong framework for moral healthcare data management. It also results in a patient-centric approach to data protection. GDPR's emphasis on individual rights and FHIR's emphasis on patient data accessibility combine to give patients more control over their health information. By ensuring that patient data shared via FHIR stays within GDPR regulations, our solution promotes openness and trust among patients, healthcare providers, and other stakeholders such as insurance companies. Additionally, this integration not only enhances interoperability but also serves as a risk mitigation strategy.

According to Article 5.1.c of General Data Protection Regulation, personal data should be “adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed (‘data minimisation’)”. The GDPR places a strong emphasis on the idea of data

minimization, supporting the gathering and use of only the personal information that is required for given purposes. This idea is reflected in WristFlow Navigator, which carefully specifies the kinds of patient data that must be processed and restricts its use to that which is necessary for running our product to improve healthcare processes and also giving clarity to stakeholders. Only pertinent data is processed, protecting patient privacy by avoiding needless or excessive data collection.

Moreover, our product complies with article 5.1.b, which states “personal data shall be collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes; further processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes shall, in accordance with Article 89.1), not be considered to be incompatible with the initial purposes (‘purpose limitation’)”, by outlining the precise goals of the processing of patient data. Any additional data processing is in line with the initial healthcare goals that informed the data's collection.

Individuals are granted certain rights under GDPR with regard to their personal data, including the ability to access, correct, delete, and limit the processing of their data. Mechanisms that enable people to successfully exercise their rights are part of our solution. In accordance with GDPR regulations, patients have the right to access, request corrections, have their health data restricted, or have it deleted. This promotes accountability and transparency while guaranteeing compliance and giving people firm control over their personal information.

Strong data security measures are required by GDPR to guard against unauthorised access, disclosure, alteration, and destruction of personal data (Article 32, GDPR regulation). To protect patient information, our solution uses cutting-edge security protocols, encryption techniques, access controls, and recurring security audits. By putting data security first, we not

only meet GDPR requirements but also give patients and stakeholders peace of mind about the integrity and confidentiality of their health data.

According to articles 12 and 13, GDPR mandates the lawful, equitable, and transparent processing of personal data. Because it complies with the GDPR's list of permissible bases for processing, WristFlow Navigator guarantees legal compliance. Furthermore, we uphold transparency in all aspects of our data processing operations by offering easily understandable privacy policies and consent mechanisms. In keeping with GDPR requirements, patients are notified about the processing of their data, creating a transparent and reliable relationship.

Under the Article 9.1 of the GDPR the processing of personal data revealing data concerning health shall be prohibited. However, it should not be applied if one of the mentioned reasons on the Article 9.2 is valid. Our solution is covered by the article 9.2.a, “the data subject has given explicit consent to the processing of those personal data for one or more specified purposes” and by the article 9.2.h, “processing is necessary for the purposes of preventive or occupational medicine, for the assessment of the working capacity of the employee, medical diagnosis, the provision of health or social care or treatment or the management of health or social care systems and services on the basis of Union or Member State law or pursuant to contract with a health professional and subject to the conditions and safeguards referred to in paragraph 3”.

5.10.2 HIPAA Compliance

In 1996, the Health Insurance Portability and Accountability Act (HIPAA), which can be found on the Title 45 of the Code of Federal Regulation part 160, part 162 and part 164, was enacted as a comprehensive U.S. federal law to regulate and safeguard personal health information from being disclosed or misused. HIPAA is crucial for healthcare organizations and entities that

handle protected health information (PHI) as it deals with several healthcare data protection and privacy concerns.

The Privacy Rule comprises how covered entities, or entities subject to its provisions use and disclose PHI, such as health plans, health care providers, health care clearinghouses and business associates. It establishes guidelines that guarantee people's rights to know and decide how their health information is used. Ensuring appropriate protection of people's health information while enabling the information flow required for the provision and improvement of high-quality healthcare is the main goal. In order to safeguard the health and welfare of the general public, the Privacy Rule is essential. The rule also sets restrictions and limitations on the uses and disclosures of PHI without individual consent, as well as necessary measures to protect its privacy. People have certain rights, such as access to and inspection of their health records, authorization to send an electronic copy of their PHI to another party, and the right to ask for changes to be made to their health information (OCR, 2022).

A subset of the data covered by the Privacy Rule is protected by the Security Rule. All individually identifiable health information created, received, maintained, or transmitted in electronic form by a covered entity is included in this subset. To comply with the HIPAA Security Rule, all covered entities must ensure the availability, confidentiality, and integrity of all e-PHI. They must also identify and guard against potential security risks and prevent any unlawful use or disclosure of protected information. Additionally, covered entities are required to certify that their employees are following the guidelines (OCR, 2022).

5.10.3 Geographical Regulatory Environment

Both the Health Insurance Portability and Accountability Act (HIPAA) and the General Data Protection Regulation (GDPR) aim to safeguard personal information, but they vary in terms of their scope, objectives, and extent. The main difference between the regulations is their

geographical applicability. While GDPR is a European Union (EU) regulation that governs the processing of personal data pertaining to individuals within the EU and the European Economic Area (EEA) and also to non-EU organisations that process data belonging to EU citizens as well, the HIPAA is a federal law in the United States that predominantly impacts healthcare clearinghouses, health plans, and providers operating within the nation, including their affiliated associates (HIPAA, 2022). Moreover, GDPR prioritises the empowerment of individuals (data subjects) by giving them comprehensive control over their personal data. This control extends to the ability to access, correct, delete, and limit the processing of their data. On the other hand, HIPAA focuses on the establishment of guidelines for keeping medical records secure rather than safeguarding the rights of individuals covered by the law, also referred to as protected health information or PHI.

WristFlow Navigator is not considered a medical device, however, if we intended to involve functionalities related to monitoring health parameters it then falls into the category of medical devices and other legal framework must be followed. According to the World Health Organization, “a medical device can be any instrument, apparatus, implement, machine, appliance, implant, reagent for in vitro use, software, material or other similar or related article, intended by the manufacturer to be used, alone or in combination for a medical purpose”. Depending on the geographical area where is intended to be used or advertised, it would need to comply with different medical devices regulations, such as Food and Drug Administration (FDA) in the United States, Therapeutic Goods Administration in Australia, in Japan, the Pharmaceuticals Medical Devices Agency (PMDA), Good Manufacturing Practices (GMP) in Brazil, and so on (Gupta, 2015), Medical Device Regulation (MDR), an update version of the MDD first redesigned in 2017 after being founded in 2007 (Kobridge, 2020), in the European Union.

Generally, medical devices are categorised into distinct classes according to the degree of regulatory oversight required to guarantee their effectiveness and safety. The classification process usually takes into account various factors, including the device's intended use, potential for harm, and the level of scientific evidence needed for regulatory review. It is noteworthy that regulatory agencies may have different classification systems. Moreover, there are less regulations governing lower class devices.

In conclusion, our solution is carefully developed to meet the strictest regulatory compliance requirements, including the Health Insurance Portability and Accountability Act (HIPAA), the General Data Protection Regulation (GDPR), and relevant medical device legislation. Our strategy, which is in compliance with GDPR, places a high priority on the moral and legal processing of patient data while maintaining strict privacy protections. Our dedication to protecting electronic protected health information, upholding confidentiality, and securing healthcare information is demonstrated by our compliance with HIPAA regulations, allowing us to grow into bigger markets like the United States. This steadfast dedication to adhering to regulations fosters confidence among users and stakeholders and establishes our solution as a reputable and morally sound option in the healthcare industry.

5.11 Scalability and Growth Plans

WristFlow Navigator’s scalability and growth plans are strategically crafted to meet the changing demands of healthcare organisations while guaranteeing a smooth and effective expansion process.

5.11.1 Methodical Implementation Process

Our solution is designed to be adaptable to the unique needs and complexities of various healthcare settings, allowing for seamless integration into existing workflows. Recognising the

diversity of operations, from large hospitals to specialised clinics, our solution's adaptability ensures its utility in a variety of healthcare environments. Starting our implementation process requires a careful and methodical approach to guarantee a smooth integration and long-term success in a variety of healthcare settings. The first step to successfully implement our product is to conduct a thorough assessment in conjunction with the healthcare facility by interacting with key stakeholders, such as administrators, medical professionals, and IT teams, which will provide a comprehensive understanding of their specific needs, challenges, and overall goals with our product. Consequently, a customized plan will be set up based on the information obtained from the needs assessment, that is aligned with those demands. It is crucial that the solution is as seamless as possible and compatible with the workflows, procedures, and organizational framework of the medical field.

One of the main ideas behind WristFlow Navigator is interoperability. It creates a harmonious and unified approach to cost management by integrating with current healthcare systems with ease. This guarantees seamless integration of our solution into healthcare settings using pre-existing technologies, minimizing disruptions, and maximizing interoperability. The ability of our solution to be interoperable is essential to its scalability and long-term sustainability.

Our product is built around standardised data exchange, by integrating the data extracted by the RFID tags and complementing with the data extracted by the hospital existing software, which is possible by using Fast Healthcare Interoperability Resources (FHIR). By enabling uniform and thorough sharing of healthcare data across various systems, this dedication to data standards promotes a unified and interconnected healthcare ecosystem.

Before publicly launching the product, a testing or pilot implementation is imperative carefully performed in a controlled environment within the healthcare industry, reducing possible interruptions while methodically assessing the product's dependability and performance. This

crucial stage fulfils a variety of purposes allowing to the gather constructive feedback from stakeholders on its overall use and understand, identifying potential issues, challenges that may arise and its limitations. Issues must be addressed promptly in order to improve and optimise the product for smooth integration. This phase is vital to expanding our knowledge of the legal environment that surrounds personal health data collection and to ensure adherence to the laws and guidelines that apply to the use of our technology.

Applying a continuous feedback based iterative procedure based on ongoing feedback is important to make sure that everything is always running smoothly and that all the issues are visible and being addressed, ensuring that the product adapts to actual use and reflects the dynamic needs of the healthcare industry. Assisting with continuous technical support and troubleshooting techniques to quickly resolve any problems and communicate with healthcare personnel on a regular basis to get their opinions and gauge user satisfaction.

5.11.2 Diversified Revenue Streams and Future Market Penetration

It is important to highlight our present advantages in serving small to medium-sized clinics or hospitals that specialise in particular medical issues, allowing to implement RFID and process mining more effectively. This phased approach puts us in a strategic position for future expansion into larger hospitals and diverse healthcare organisations. Building trust and understanding with prospective clients and stakeholders will require open communication about our roadmap for technological advancements and scalability. Consider factors such as institutional size, infrastructure, and geographic location as gradually extending the implementation to more healthcare facilities, by leveraging the insights gathered on the previous real-world testing experience. Forming alliances with major industry players, tech suppliers, and healthcare associations is integral to our strategy, we must use these alliances to

obtain important information, get access to more resources, and improve the integration capabilities of the solution.

To achieve scalable implementation, our approach consists of multiple components. Thorough cost management techniques are used at every stage of implementation to guarantee cost-effectiveness. This entails focusing on operational efficiency, conscientious resource allocation, and strict budgeting. Infrastructure and technology investments are given priority, and capital expenditures are systematically matched with scalable growth. Therefore, it is crucial to dedicate funds to ongoing research and development so that we can lead the way in innovative healthcare technology while anticipating new developments in technology and seamlessly incorporate them into the solution, by keeping a competitive edge.

For scalability and sustainability, diversifying revenue streams via product sales to particular industries and data monetization is a forward-thinking approach. We can give pharmaceutical companies and pharmacies vital insights into market trends, patient behaviours, and healthcare utilisation patterns by compiling and anonymizing the valuable data gathered by WristFlow Navigator. This creates a new source of income and establishes our product as a useful component of the larger healthcare system.

Furthermore, investigating the possibility of offering the complete product for sale to retirement communities is consistent with our dedication to meeting the changing requirements of various healthcare environments. Retirement communities could greatly benefit from the extensive features provided by our solution, given their particular needs for patient care and activity monitoring. This strategy not only increases market penetration but also positions our product as a flexible and adaptive solution that can be used in a range of healthcare settings.

5.12 Risk Assessment and Mitigation

Implementing our healthcare solution will require careful consideration of potential risks and proactive risk management. Diverse challenges can emerge in the complex landscape of the healthcare sector.

Regulations pertaining to the healthcare industry are constantly changing, and breaking the law can be extremely risky. To mitigate the risk of not complying with all the regulations we should hire a specialised legal team with knowledge of healthcare laws, including the strictest data protection regulations, such as GDPR and HIPAA, when expanding to the US market. To make sure compliance with evolving regulatory requirements is maintained, regular compliance audits will be carried out. To stay ahead of any obstacles, open lines of communication will be maintained with regulatory agencies.

Adoption may be hampered by incompatibility with current healthcare systems and resistance to technological change. That is the reason why we prioritise and focus so much on interoperability, we will carry out thorough compatibility analyses by using FHIR as our main interoperability standard. A smooth integration process will be facilitated by interacting with current healthcare technology providers and providing comprehensive training programmes.

Our solution may not be successful if healthcare personnel and professionals are resistant to change. User-friendly interfaces and extensive training programmes will be developed in order to address this. Participating end users in the phases of design and testing guarantees that the solution meets their needs. Sustained assistance throughout the transitional phase will promote user adoption even more. Workflow disruptions and resistance to organizational changes may impede the effective application of our solution. A comprehensive plan for managing change will be formulated, encompassing open and honest communication, involving significant stakeholders in the decision-making process, and providing continuous support to ensure a

seamless transition. Moreover, our solution is non-invasive, which means that there is no need of personnel, such as nurses and doctors, to perform a certain task for the solution to work, as the sensors will be placed at the doors so that the resources can be tracked immediately with no additional effort from the staff.

It's critical to recognise and address scalability issues early on. Our system will have a scalable architecture and undergo frequent performance metrics evaluations. Our objective is to guarantee that our solution can easily expand to accommodate rising demand by forecasting growth trends and making appropriate infrastructure investments, mainly on cloud-based infrastructures to manage growing user and data loads. Additionally, invest also on targeted marketing campaigns to raise awareness and attract new clients.

Budget allocations for technology solutions may be impacted by economic downturns, and the healthcare sector is not exempt from them. We will offer flexible pricing models and diversify our revenue streams to reduce this risk. Having emergency funds set up and keeping financial records transparent will allow for flexibility in response to shifting market conditions.

There are inherent risks associated with relying on outside vendors and possible supply chain disruptions. We will maintain alternate suppliers, cultivate strong relationships with vendors, and regularly evaluate the supply chain's risk. Contractual agreements will have backup plans to handle unanticipated difficulties.

6. Discussion

How our solution creates value to Organizations

Our proposed solution, designed to streamline Time-Driven Activity-Based Costing (TDABC) in healthcare settings, represents a significant step forward in enabling healthcare organizations to implement TDABC effectively. The core components of our proposal synergize to create a

semi-automated TDABC process that can be implemented in a hospital setting and have a positive impact on the overall value delivered to patients. In fact, each technology or feature that we propose in our solution contributes to creating value to healthcare organizations.

Central to our idea is the strategic use of RFID technology. This technology plays a critical role in automating the tracking of activities and resource utilization, significantly reducing the likelihood of manual data entry errors and the associated administrative workload. The precision of RFID technology in tracking patient movements and activities within healthcare facilities is extremely valuable and it provides accurate data essential for the allocation of costs in TDABC, ensuring that every aspect of patient care is accounted for. Additionally, RFID allows for the above advantages without increasing the workload of Medical Doctors and staff, thus facilitating the overall process of acceptance and implementation.

Complementing RFID technology in our solution is the adoption of process mining techniques. Combining TDABC with process mining considerably reduces the time and resources required to map the activities that patients undergo in a hospital. We utilize the open-source process mining framework PM4PY that uses Python to apply process mining algorithms. For our solution, we apply the currently best performing algorithm for discovering processes which is the Inductive Miner algorithm. We use the Inductive Miner - directly-follows framework to enhance the understandability and generalization of the pathway. By developing an in-house solution, we mitigate costs and trust issues that healthcare organizations might otherwise have. Furthermore, we have the flexibility to constantly review and adapt our techniques to the state-of-art.

Process mining techniques are instrumental in converting complex patient data into clear, actionable insights. Therefore, they enable not only a fast and detailed mapping of clinical processes, but also allow doctors to identify and flag inefficiencies, pinpointing areas that

necessitate improvements, and redesigning processes that are non-functional to the specific medical condition treated. By visualizing the entire patient care pathway, healthcare organizations can also gain a deeper understanding of resource allocation and patient flows. This is crucial for the effective implementation of TDABC, as it allows for a more nuanced approach to healthcare cost management, aligning closely with patient needs and care patterns.

Furthermore, the integration of our solution with Hospital Information Systems (HIS) is another cornerstone of our approach. This integration ensures a smooth and seamless transition of data, maintaining the integrity and accuracy of information crucial for effective cost tracking and resource allocation within the TDABC framework. Additionally, aligning our solution with the Fast Healthcare Interoperability Resources (FHIR) emerges as a paradigm-shifting framework that overcomes the drawbacks of conventional interoperability standards in healthcare data exchange. It guarantees integration with modern technologies with ease and simplicity. Because of its extensibility, FHIR can be tailored to changing healthcare needs, resulting in a more intuitive understanding of data. FHIR is an essential part of TDABC solution because it makes real-time information flow standardized and interoperable, which is necessary for precise cost calculations and well-informed decision-making in the ever-changing healthcare environment. Moreover, its standards set forth by the European Union adds another layer of feasibility, scalability, and sensitivity to privacy concerns. This compliance ensures that our solution is not only technically sound, but also adheres to the strict regulatory requirements of healthcare data management.

Challenges and Limitations of our solution

While we believe that our solution has enormous potential, we are also faced with several challenges and limitations in implementing it in a real-world context. Being a highly innovative and transformative solution, its successful implementation in healthcare organizations requires

a mindset shift and committed professionals who are invested in ensuring the success of the solution. Ultimately, we need to target management level and field staff who will directly work with our solution on a daily basis. To ensure a smooth transition, our solution needs to be supported by a strong onboarding and training process that facilitates buy-in across all stakeholders.

We identified the optimal technology solutions to automate TDABC, which are RFID and process mining. However, there are several trade-offs between simplicity and precision for RFID, where we needed to make a decision to fulfill our priorities. Likewise, for process mining, the algorithms are not optimal and include risks such as creating blind spots through too much filtering.

Furthermore, in order to capture the value created by our solution, the creation of entry barriers is key to ensure that other parties may not easily replicate our solution and business model. Finally, as several initial investments are required to initiate the transition to semi-automated TDABC, it is important to ensure that these investments are feasible for the hospitals interested in our solution, and that our business model is properly structured to make the initial set-up costs as low as possible for organizations. In the below sections, we address in depth the major challenges and limitations of our solution from multiple perspectives.

Stakeholders' Buy-In

In the specific case of our proposal, the success of our solution strongly depends on the willingness of medical professionals and management team to embrace change. A shift in mindset towards patient care and administrative processes is crucial for the effective implementation of our solution. Without broad-based acceptance and commitment, the feasibility of real-world implementation is significantly diminished, as well as the potential benefits of our solution. Moreover, to obtain financial data from a particular healthcare

organization, we need the trust and commitment from the medical staff to provide us with the necessary information. They need to be invested in implementing our solution so that they share their sensitive data with us and their time and resources.

For these reasons, our proposal poses a great emphasis on the need to support the transition to TDABC with intense personnel training and formation, involving MDs, nurses, managers and IT and HR personnel.

RFID

There are different levels of granularity that we can pursue regarding how detailed we want to record the data. In our solution, we capture the data of the overall activity and ignore the single actions of the medical staff that are involved. For instance, when a patient has a consultation with a medical doctor for 50 minutes, our RFID system will track the activity "consultation" and the resource medical doctor for 50 minutes. However, if the medical doctor has given the patient a vaccine during the consultation in the same room, we will not record this to make our solution simpler. This has the disadvantage that there might be important information that we will forego which could help optimize the pathway. Ultimately, we are trading-off precision with simplicity. We mitigate the issue by implementing a planning schedule with the management team and medical staff that ensures that a certain kind of activity is conducted in a certain room. Thus, by allocating activities to a set of rooms and limiting the amount of activity that can happen in each room, we have more accurate information on the activities in a certain room.

In general, it is noteworthy to mention that our focus is to implement TDABC by creating pathways. By being too detailed, we might lose focus on the ultimate goal – to record the resources and times spent per resource; hence, having an overall picture of the activity would also suffice for our solution.

Process mining

Algorithms are constantly evolving. In the current state-of-art, there is no process mining algorithm that performs well on all four quality criteria, namely soundness, generality, precision, and fitness. In our solution, we apply the Inductive Miner—directly-follows framework and the conformance checking framework to discover and improve pathways. We evaluated them to be the best performing algorithms compared to other common algorithms measured on all four criteria overall. Nonetheless, by filtering to ensure sound and simple process mining models, we might not reflect the entire real-world pathway. We remove outliers in the process and do not reveal infrequent behavior. An issue could arise when these infrequent behaviors contain valuable information, for instance information on inefficiencies and obstacles that medical staff face in their day-to-day work. By filtering out infrequent behavior from the event log, we could forego valuable knowledge and the opportunity to obtain a holistic view of the process.

We are limited by the technological advancement as there is no process mining algorithm which captures the variability while having the ability to develop meaningful pathways that healthcare professionals can understand and utilize. Thus, we will constantly improve our solution as there are new and better option for process mining algorithms available with time.

Patent and Replicability Protection

Our innovative use of RFID technology in healthcare cost management is not easily patentable, making it vulnerable to replication by second-mover parties with more resources. To mitigate this risk, transforming RFID wristbands into certified medical devices could be a strategy, albeit increasing costs and legal complexities. However, our know-how and specialized expertise is not easy to imitate. Hence, other parties might be able to replicate certain parts of our solution,

but offering a holistic end-to-end solution that enables the implementation of TDABC such as ours would be difficult.

Initial Investment Required

The implementation of our solution requires significant upfront investment from healthcare organizations. This includes the procurement of RFID tags in large quantities, mining large data logs, comprehensive staff training, and potential expansions or enhancements in IT infrastructure and personnel. These initial costs may pose a barrier for some institutions, particularly small institutions with limited financial resources. Accounting to the fact that healthcare organizations would not have the knowledge of how much their cost structure would decrease by implementing TDABC, we can expect a certain hesitation from the healthcare organizations to make such a huge financial investment.

We can provide some exemplary calculations how much they could potentially save from other organizations who have introduced TDABC in their organization to decrease doubts. Furthermore, discussing on the government level to fund projects that aim to implement TDABC to improve value for patients could solve this challenge.

7. Conclusion

In this work project, we addressed the flaws in the current costing systems and discussed the need for a new costing system. Current costing systems fail to capture the true cost of patient care as they lack cost tracking mechanisms as well as accurate and granular cost data.

As an integral part of the transformative Value-Based Health Care concept, we introduced Time-Driven Activity-Based-Costing which enables organizations to track resources and costs for a specific treatment. TDABC observes all activities in the entire healthcare process or care pathway and measures all the resources and the time spent of each resource that was devoted

to each activity. This allows a precise assessment of resource utilization. Moreover, by examining every step of the care pathway, we can observe bottlenecks and obtain relevant information to improve the processes.

Having outlined the significant contribution of TDABC to enhance patient care quality, we proposed an end-to-end solution for implementing semi-automated TDABC in healthcare settings which represents a ground-breaking approach to healthcare cost management. Our interviewees emphasized the need for an automated solution as medical staff would otherwise be reluctant to commit to implement the solution. As they are burdened with a high administrative workload, finding a solution that demands as little time from medical staff as possible generates a higher commitment and success rate. Another benefit that automation delivers is the consistency and accuracy of the data that we gather which is possible through RFID technology.

We explained that RFID technology is superior to other common technologies to track assets such as equipment, medications, and people in terms of ease of adaption and high integration capability, low cost of devices, and efficiency. To increase accuracy, we suggested both hospital staff and patients to wear RFID wristbands. We also described that we would place the readers at the door of each room and allocate a certain function for each room. This enables us to know which activity was done based on the room. We highlighted the importance of determining which patient data to collect as it varies depending on the disease. Basic patient demographics as well as clinical data are essential, which can be collected from the hospital software. We also discussed interoperability standards when exchanging data between the different eHealth systems and introduced the FHIR framework. Together with the activity data that we collect automatically with the RFID wristbands and the financial data, we gathered the necessary data to visualize the care pathway with the respective activities and costs.

We discussed the benefits of process mining to discover processes and to visualize care pathways in a way which medical staff can comprehend easily. We use the process mining framework PM4PY which uses Python to apply process mining algorithms. We discussed the four crucial quality criteria soundness, fitness, precision, and generalization for process mining algorithms and the challenges of generating an unstructured model known as the spaghetti model due to the variability and magnitude of healthcare data. To counteract this issue, an interviewee emphasized the importance of filtering, aggregation, and clustering techniques to minimize the complexity. We explained why the Inductive-Miner – directly-follows framework is best to discover a process, evaluated based on its performance on the four quality criteria. To compare processes, we introduced conformance checking, for which the Projected conformance checking framework is the best alternative as it can handle large logs while performing well on the quality criteria.

By leveraging RFID technology, process mining, and seamless HIS integration, we offer a comprehensive, efficient, and precise method for tracking and analyzing healthcare service delivery and resource utilization. Our approach not only simplifies the complexities associated with TDABC but also aligns with the evolving needs of Value-Based Health Care models. We proposed a business model while identifying a competitive advantage due to the uniqueness and complexity of our solution that requires a distinct set of expertise and know-how. By targeting hospitals and insurance companies, we enable them to obtain more transparency and informed decision-making regarding costs, pricing, negotiating contracts, and budget allocation. We introduced an engagement plan to reach our target customers which includes educational workshops and training programs for medical staff and insurance company employees. Furthermore, we ensured that our solution is compliant with GDPR and HIPAA.

Given the complex setting and multiple layers of our solution, we acknowledge the challenges, including the need for stakeholder buy-in, replicability protection, and significant initial

investments. Nonetheless, the value and significance of our solution in enabling healthcare organizations to optimize their cost management and improve patient outcomes cannot be overstated. We will ensure that we update our technology and leverage the technology advancements of RFID and process mining to always incorporate the state-of-art. For RFID, we aim to further reduce the currently required involvement of medical staff to collect data. Concerning process mining technology, we will continuously update the algorithms based on the emergence of new and better performing process mining algorithms. By addressing the current limitations and continuously refining our approach, we are confident that our solution will play a pivotal role in shaping the future of healthcare cost management and patient care delivery.

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9. Appendix

Glossary

VBHC – Value-Based Healthcare

TDABC – Time-Driven Activity-Based-Costing

IPU – Integrated Practice Unit

RFID – Radio-Frequency Identification

NFC - Near-Field Communication

BLE - Bluetooth Low Energy

RTLS - Real-Time Location Systems

MD – Medical Doctor

UZ Gent – University Hospital of Gent

EHRs - Electronic Health Records

PM4PY – Process mining Framework by the Fraunhofer Institut

ImD framework – Inductive Miner direct-follows framework

PCC framework - Projected Conformance Checking framework

- **HL7** or **Health Level Seven** it is used by Health care providers as a set of international standards, to transfer clinical and administrative data between software programs. They concentrate on the OSI (Open System Interconnection) model's application layer, also known as layer or level 7, and offer data standards and methodologies to enable consistent clinical information communication across various healthcare systems (ExtraHop, 2022).
- **Application Programming Interface (API)** is an entry point or interface which allows the communication and access the features and data between different software systems. This entry point defines how data must be formatted and the types of interactions supported, such as how data can be searched. Building integrated and interoperable software applications requires the use of APIs (FHIR Fact Sheets).
- **REST stands for Representational State of Transfer** and it is a type of architecture used to create networked applications. REST is a method of exchanging information using the World Wide Web standard transfer protocol HTTP (beginning of webpage's web address), the underlying internet standard that forms the basis for all website data exchange. A "**RESTful**" exchange is one in which REST is used to exchange data. A

RESTful Resource provides a mechanism to retrieve data using formats and structures via a designated endpoint (FHIR Fact Sheets).

Table 1: Interviews

	Full Name	Working Country	Organization	Profession	Expertise
1	Niels Hilhorst	Belgium	University Hospital of Gent	MD	Implemented TDABC for the condition of psoriasis
2	Erin Roman	Belgium	University Hospital of Gent	PhD/ researcher	Developed process maps and implemented TDABC in two disease domains, breast cancer and psoriasis
3	Joke Borzée	Belgium	University Hospital of Gent	phD/ researcher	Implemented TDABC manually in several hospitals in the conditions of lung cancer, psoriasis, and hip surgery
4	Anton Hasselgren	Norway	Accenture	Blockchain Specialist	Expertise in blockchain technology in healthcare
5	Eduardo Alves Portela Santos	Brazil	Federal University of Paraná	Professor	Process mining

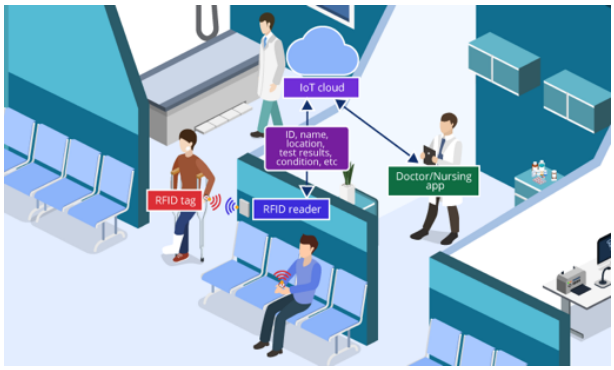

Figure 1: Smart Patient Tracking with RFID. Source by Shiklo, 2018.

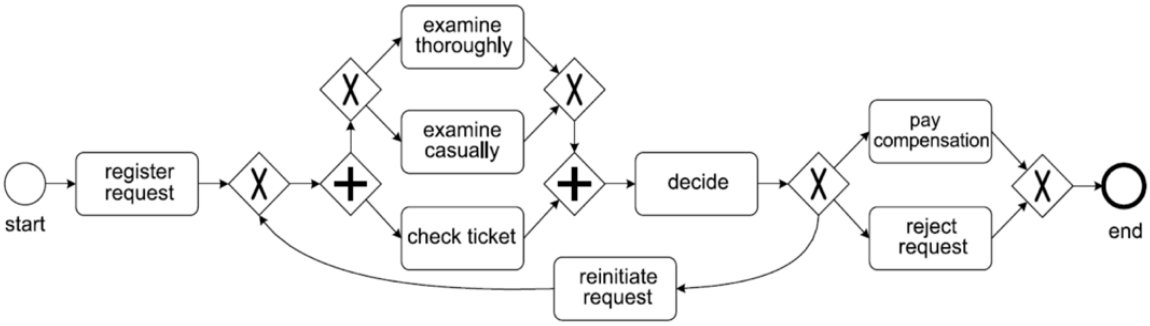

Figure 2: BPMN diagram. Source by Fraunhofer Institute for Applied Information Technology, 2023.

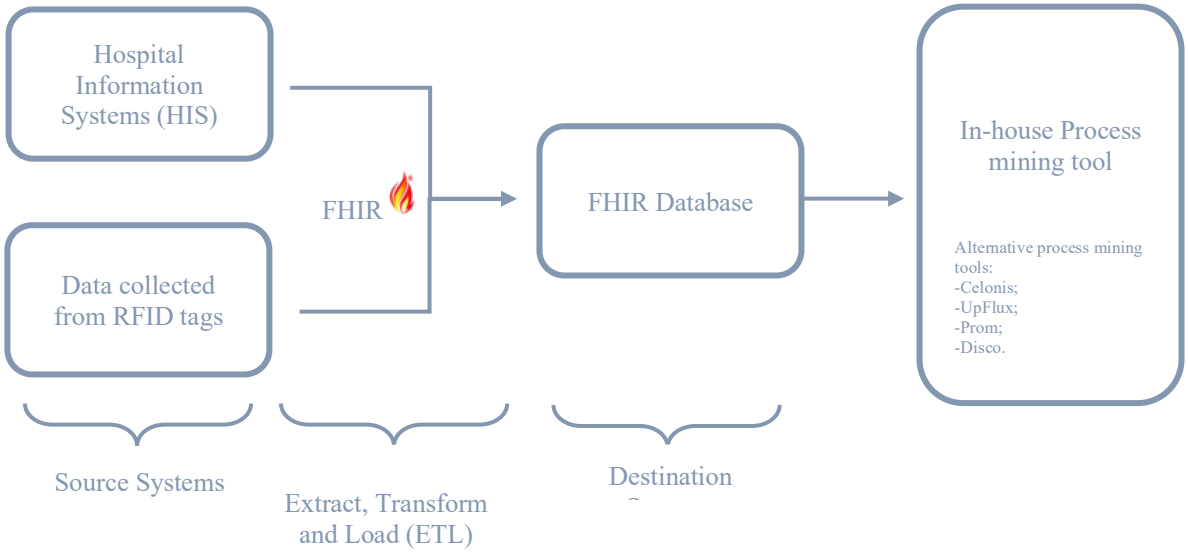

Figure 3: Data Flow. Source by Anonymous FHIR expert, 2023.