A Work Project, presented as part of the requirements for the Award of a Master's degree in Management from the Nova School of Business and Economics.

"Implementing Automated TDABC In Healthcare Settings – Creating Value For Patients and Organizations"

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19/01/2023

Abstract

This work project proposes a comprehensive solution to implement and automate TDABC in healthcare settings. The core of our proposal is an innovative approach that integrates RFID technology and process mining to streamline data collection and process mapping. By combining academic literature with insights from medical doctors and industry professionals, we highlight the advantages of TDABC over traditional costing methods, and outline all steps required for a practical 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

Mandatory Funding Statement

The authors received no financial support for the research, authorship, and/or publication of this article.

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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. Contextual Background

2.1 Challenges in Healthcare Cost Management and Limitations of Manual Approaches

In the realm of healthcare, cost management poses as an intricate challenge. This complexity stems from the multifaceted nature of healthcare delivery, where patient outcomes, quality of care, and economic efficiency must be balanced meticulously. A significant issue in this sector is the escalating healthcare costs, which continue to rise at an unsustainable rate. According to a study by Papanicolas et al. (2018), the United States, in particular, faces disproportionately high healthcare expenditures compared to other high-income countries, without corresponding improvements in patient outcomes.

Traditional cost management approaches in healthcare have primarily been volume-based, focusing on the quantity of services delivered rather than their quality or relevance to patient outcomes. This approach, as elucidated by Kaplan and Porter (2011), often leads to inefficiencies and misaligned incentives when delivering patient care, where healthcare providers are compensated more for the number of procedures performed rather than their

effectiveness. Consequently, this can result in unnecessary treatments, overutilization of services, and elevated costs without commensurate health benefits.

Another critical limitation of conventional methods is the lack of accurate and granular cost data. Traditional costing systems, as highlighted by Rosenthal and Milstein (2017), often allocate indirect costs arbitrarily, failing to capture the true cost of patient care. This can lead to inaccurate pricing, misinformed decision-making, and an inability to identify areas for cost reduction and quality improvement. Moreover, the dynamic and evolving nature of healthcare, characterized by rapid advancements in technology and changing patient demographics, further complicates cost management. Traditional approaches, often rigid and outdated, struggle to adapt to these changes, making them less effective in contemporary healthcare settings.

Overall, the challenges in healthcare cost management are multifaceted, stemming from the sector's inherent complexities and the limitations of traditional cost management approaches. These approaches, driven by volume-based incentives and inadequate cost tracking mechanisms, are ill-suited for the evolving demands of healthcare delivery models. Addressing these challenges necessitates a shift towards more innovative, value-based costing models that emphasize the relevance of patient outcomes, cost-effectiveness, and adaptability to changing healthcare dynamics.

This problem contextualization will be more detailly explained in section 4.

2.2 Introduction to Value-Based Health Care (VBHC)

In the evolving landscape of healthcare, Value-Based HealthCare (VBHC) has emerged as a transformative framework. Conceived by the distinguished economists and strategists Michael E. Porter and Elizabeth O. Teisberg, it represents a profound departure from conventional healthcare delivery models, transcending the confines of fee-for-service and capitated payment

systems. The concept of VBHC is founded on a holistic approach to healthcare delivery, highlighting the importance for organizations to adopt a patient-centric approach. The objective at core is to continuously enhance the value provided to patients by focusing on improving health outcomes and managing costs with insightful accuracy (Kaplan, 2016).

Central to the VBHC framework is the reorganization of healthcare delivery around specific patient segments or medical conditions, an approach that challenges the traditional departmental structure of hospitals. The essence of this restructuring lies in the formation of Integrated Practice Units (IPUs), which are multidisciplinary teams dedicated to providing comprehensive care for specific medical conditions or patient segments. IPUs bring together experts from various specialties to collectively address the full spectrum of patient needs within a specific care pathway (Porter & Teisberg, 2006). Each IPU operates as a self-contained unit responsible for the entire patient journey, from diagnosis to post-treatment care. This fundamental shift away from fragmented care models ensures that patients receive coordinated, seamless, and patient-centric care that transcends the boundaries of individual specialties. In doing so, IPUs enhance care quality, streamline processes, and reduce the likelihood of redundant or unnecessary services (Porter & Lee, 2013). Furthermore, organizations that have already, at least partially, transitioned to the IPU structure have a proven record of delivering faster treatments, improved outcomes, and have achieved lower costs as well as increased market share for the condition in which the IPU is implemented (Porter & Lee, 2013).

Even more importantly, the implementation of a comprehensive approach to patients' conditions allows for more accuracy in monitoring the overall care delivered to patients, including resource efforts and the associated costs. Consequently, it also becomes easier to assess the true outcome provided to patients, measured as: Patient's health outcomes / Total Cost of delivering patient care.

In fact, one of the defining features of VBHC is its unconditional commitment to measuring value by assessing outcomes relative to costs across the entirety of the care cycle. In this framework, "value" is defined as the ratio of health outcomes achieved to the costs incurred. Unlike traditional healthcare delivery models that often compartmentalize cost and outcome measurement, VBHC insists on evaluating both in conjunction, embracing a comprehensive view of healthcare value (Porter, 2010).

This rigorous evaluation of the value delivered to patients extends beyond individual services or isolated encounters and encompasses the entire care journey. Furthermore, this holistic assessment enables healthcare organizations to obtain a profound understanding of the impact of care on patient health, facilitating the identification of areas for improvement, resource optimization, and the elimination of inefficiencies. By shifting the focus from mere service volume to consistently improving patient outcomes, VBHC realigns incentives towards delivering superior value to patients across all stakeholders involved, while simultaneously enhancing cost-effectiveness (Porter & Kaplan, 2011) (Porter & Lee, 2015).

2.3 Relevance of Cost Measurement in Healthcare Settings

Having established the foundational principles of Value-Based Health Care (VBHC) and its implications for healthcare delivery models, it becomes clear that the key objective of the VBHC framework, improving patient health outcomes while effectively managing costs, requires a rigorous and well-defined approach to cost measurement (Kaplan & Anderson, 2004). While IPUs have demonstrated their effectiveness in delivering streamlined, patient-centric care, they also underline the need for enhanced cost measurement systems that allow organizations to track resources, costs, and outcomes with unparalleled precision (Kaplan & Anderson, 2004).

2.4 Achieving Accuracy in Cost Measurement

VBHC places a premium on precision in cost measurement, as it seeks to evaluate value by assessing patient outcomes against the costs incurred throughout the full care cycle (Porter, 2010). One of the key drivers behind the demand for better cost measurement systems in the context of VBHC is the imperative to enable organizations to build their budgets from the bottom-up (Kaplan & Porter, 2011). Traditional top-down budgeting models, which allocate budgets to departments or service lines based on historical spending patterns, are ill-suited to the dynamic and value-centric nature of VBHC. In addition to this, they also lack the granularity required to measure costs accurately at the level of individual activities and resources.

In fact, VBHC stresses the relevance of implementing a budgeting approach that is grounded in a detailed understanding of the costs associated with specific patient conditions and the required care pathways they will need to undergo. Bottom-up budgeting, facilitated by accurate cost measurement systems, offers several distinct advantages. Firstly, it aligns financial planning with the principles of value and patient-centricity, ensuring that resources are allocated to activities and interventions that directly contribute to improved patient outcomes (Kaplan & Witkowski, 2014). This approach also allows organizations to identify areas of inefficiency and waste, facilitating targeted process improvements and resource optimization (Kaplan, 2016). Furthermore, it enhances transparency in financial decision-making, enabling organizations to allocate resources where they are most needed, thereby enhancing value for patients.

It cannot be emphasized enough that the successful implementation of this bottom-up budget relies on the presence of accurate cost measurement systems. Without such systems or methodologies in place, how will there be cost planning at an individual patient level? The foundation for any accurate cost planning inherently lies in a system that facilitates meticulous and reliable tracking from the very beginning.

Notwithstanding, the need for enhanced cost measurement systems extends beyond the specific requirements of VBHC. In an historical period where healthcare costs constantly increase and represent a growing burden for institution and governments, the ability to accurately measure and manage costs is of paramount importance for healthcare organizations across the industry. Even without the adoption of the VBHC framework, healthcare organizations can improve their financial sustainability, enhance the allocation of resources, and deliver higher value to patients (Porter & Teisberg, 2006) by adopting advanced cost measurement systems.

Having this concept of enhanced cost measuring system centrally positioned in the broader context of VBHC, the need for an accurate and efficient cost measurement tool becomes even more pronounced. As healthcare organizations increasingly transition towards value-driven models, the ability to measure costs accurately, track them comprehensively, and use this data for bottom-up budgeting and efficient resource allocation becomes essential for successfully delivering superior patient outcomes while effectively managing costs. Consequently, innovative cost measuring systems that provide the necessary precision by tracking resource consumption at the activity level have become increasingly relevant (Porter, 2010).

The subsequent sections will focus on the theoretical fundamentals and practical applications of Time Driven Activity-Based Costing, which serves as a powerful tool to meet these critical needs.

3. TDABC

3.1 Introduction to TDABC

Time-Driven Activity-Based Costing (TDABC) is an alternative approach to cost measurement and resource allocation in healthcare, originally developed by Kaplan and Anderson (2007). At its core, TDABC breaks down complex healthcare processes into discrete activities, measuring

both the time and resources devoted to each activity. Unlike traditional cost accounting methods, which can be arbitrary and less granular, TDABC offers a precise assessment of resource utilization and helps display opportunity for improvement within organizations adopting it. Before delving into the several advantages that this accounting method can bring to healthcare organizations, we first provide an overview of the high-level steps involved in the implementation of TDABC in healthcare's practices, on the basis of Kaplan and Anderson's work (2007):

1. **Define the Scope of the TDABC Framework**

First of all, it is important to focus on a specific medical condition or patient segment to provide a clear scope of the analysis. This initial step is crucial to ensure a targeted approach towards resource allocation and cost analysis.

2. **Develop Comprehensive Care Pathway**

Once the scope of the implementation is defined, process maps need to be developed. This involves detailing each activity that contributes to a patient care cycle, from admission to discharge, capturing every aspect of the care delivery process and the time spent for each activity. This step not only lays the foundation for resource and time allocation but also serves as a critical tool for process evaluation and identification of potential areas for efficiency improvement. Hence, it typically requires a collaborative effort from multidisciplinary teams to ensure its accuracy, and it is extremely time consuming and resource intensive for organizations.

3. **Resource Identification and Intensity**

At this stage, all resources utilized in the overall patient's care cycle need to be identified. In a hospital, resources typically include personnel (nurses, doctors, and administrative staff),

equipment (drugs, MRI machines, surgical instruments), and facilities (rooms, beds). Next, the intensity of resource utilization is calculated. This is done by measuring the time each resource type spends on the patient. This dual process is essential to create a clear correlation between resource allocation and patient care activities, ensuring a valid framework for an accurate cost analysis.

4. **Resource Cost Calculation**

Using aggregated financial data such as resources' annual costs and total available capacity, determine the capacity cost rate, which is the cost per minute of each resource type. This step is critical in translating resource utilization into monetary terms. Then, by multiplying the capacity cost rate of each resource for their time spent on one full care pathway, we obtain the true cost of each resource per medical condition or patient population.

5. **Integration of Indirect Costs**

Usually, when studying a medical condition, directs costs are the main driver of the analysis. Nevertheless, it is also possible to integrate indirect costs, such as rent, HR costs or IT usage, in a TDABC framework. One approach to this is to use suitable cost drivers to aggregate indirect costs at condition or department level. Alternatively, it is also possible to perform a TDABC analysis in the departments where indirect costs are generated to obtain more granular insights.

6. **Continuous Improvements Process**

The TDABC framework is not only useful to improve accuracy in cost measurement and increase cost effectiveness, but also serves as a tool for continuous process optimization. Armed with accurate cost information and clear care pathway, healthcare organizations can make

informed decisions to optimize resource allocation, streamline processes, and enhance patient care quality.

This overview only represents a summary of how the principles of TDABC can be applied in healthcare organizations. However, it is important to emphasize that to fully unlock its potential and gain valuable insights from TDABC, doctors and management team within the organization must also embrace and actively engage in the process. Gaining the most benefit from the implementation of TDABC requires a collective commitment and ongoing effort from all stakeholders involved.

3.2 Relevance of TDABC

As highlighted above, TDABC's utility extends well beyond cost measurement. It excels in mapping clinical processes to identify inefficiencies and streamline operations, optimizing resource allocation for improved quality and efficiency, and accurately predicting resource utilization for bottom-up budgeting. Furthermore, TDABC empowers healthcare organizations to gain operational know-how that enables them to better define pricing strategies, negotiate bundled payment contracts, assess the cost-effectiveness of treatments, and participate in value-based payment arrangements. In essence, the methodology equips healthcare providers with the insights needed to thrive in a value-driven healthcare landscape, delivering both quality care and financial sustainability.

The next sections present several of TDABC's multifaceted real-life applications to demonstrate how the adoption of this method can positively impact healthcare organizations.

3.2.1 Clinical Process Mapping: Streamlining and Eliminating Waste

One of the most compelling advantages of TDABC lies in its ability to comprehensively map clinical processes within healthcare organizations. In TDABC, process mapping is far more

than just a cost analysis exercise. In fact, it serves as a powerful tool for streamlining operations and eliminating inefficiencies. By dissecting the intricate steps within clinical processes, healthcare providers can identify areas where time and resources are utilized sub optimally and work on improving utilization efficiency.

For instance, a study by Kaplan and Witkowski found that, through TDABC-based process mapping, a hospital was able to identify redundancies in the pre-operative process for joint replacement surgeries. By streamlining this process and eliminating unnecessary steps, they not only reduced costs but also improved patient satisfaction by reducing wait times (Kaplan & Witkowski, 2014).

Additionally, process mapping using TDABC can reveal opportunities for enhancing coordination among healthcare professionals. For example, in the management of chronic diseases, such as diabetes, mapping the patient's journey from diagnosis to ongoing care can highlight where different specialists can collaborate more effectively, reducing the fragmentation of care and improving patient outcomes (Porter & Kaplan, 2016).

3.2.2 Optimization of Resource Utilization

TDABC's unique capabilities empower healthcare organizations to optimize resource utilization across the care cycle. This optimization extends beyond cost reduction, and it encompasses a strategic approach to care delivery that can significantly impact both quality and efficiency.

Consider the case of a large healthcare system in the United States that implemented TDABC to analyze the resource utilization in the treatment of heart failure patients. By examining every step of the care pathway, they identified areas where interventions could be performed by lower-cost healthcare providers, such as nurse practitioners, without compromising the quality

of care (Kaplan, 2016). Such redistribution of tasks not only reduced costs but also improved patient access to timely care, which in the case of heart failure conditions directly translate into increasing the likelihood of improving, or even saving, the life of several patients.

Furthermore, the TDABC methodology can pinpoint opportunities for preventive care that can yield substantial long-term savings. For instance, a review study on TDABC published in the Journal of General Internal Medicine demonstrated that hospitals adopting TDABC are generally more efficient in identifying the need for preventive screenings and early intervention for patients with chronic conditions, when compared to hospitals employing traditional costing methods (Yong et al., 2010). Hence, by adopting TDABC's principles, healthcare organizations can avoid costly complications and patient hospitalizations in later stages, ultimately reducing the total cost of care while increasing the quality of the service delivered.

3.3 Predicting Resource Utilization and Budgeting

The predictive approach of TDABC offers healthcare organizations the ability to anticipate resource utilization with remarkable precision. This predictive accuracy is indispensable for building hospital budgets from the bottom up, a practice that aligns seamlessly with the principles of value and patient-centricity inherent in VBHC.

A practical example is the one of a healthcare organization in the United States, which used TDABC to predict resource utilization for the treatment of orthopedic conditions. By accurately estimating the resources required for different patient scenarios, they were able to allocate funds strategically and ensure that resources were available when and where they were needed (Kaplan & Anderson, 2007). Moreover, TDABC's predictive power extends to forecasting future resource needs based on demographic shifts, disease prevalence, and evolving treatment modalities. For example, a study conducted by a leading academic medical center in the USA used TDABC to estimate resource requirements for the following decade to assist an aging

population characterized by an increasing prevalence of chronic diseases. This proactive approach allowed them to allocate resources effectively, preventing resource shortages and improving patient care (Domingo et al., 2018).

All in all, TDABC's applications in healthcare are clearly not limited to cost measurement; in fact, they extend into process optimization, resource utilization enhancement, and budgeting accuracy. Through the precise mapping of clinical processes, optimization of resource allocation, and predictive capabilities, it can be argued that TDABC becomes an invaluable tool for healthcare organizations striving to improve care processes, cost effectiveness, and as a direct consequence, value delivered to patients.

3.4 Pricing Strategy and Value-Based Payments

Looking beyond the above-mentioned advantages in process improvement and cost comprehension, TDABC also stands as a powerful tool that can support healthcare organizations in the implementation of innovative pricing strategies. In fact, Time-Driven Activity-Based Costing offers healthcare organizations the means to deep-dive into the cost structure of each clinical condition they manage, enabling them to set prices that are not only competitive, but also reflective of the actual resources utilized. This way, hospitals are armed with the appropriate level of granularity on their cost structure to enter into value-based agreements that are both profitable and beneficial to patients.

Consider the real-life example where a healthcare provider wants to introduce a new orthopedic surgery program. By implementing TDABC, they could accurately calculate the true costs involved in each step of the surgical process, from pre-operative assessments to post-operative care. Armed with this knowledge, they could determine a pricing strategy that not only covers their costs but also ensures a reasonable profit margin (Kaplan & Witkowski, 2014).

Furthermore, TDABC enables healthcare organizations to prepare for bundled payment contracts effectively. In a bundled payment model, a single payment is made to cover all the services related to a specific medical condition or procedure. Accurate cost measurement is thus essential to negotiate fair bundled payment rates with payers, and to ensure that the organization can deliver high-quality care while still achieving financial sustainability (Porter & Teisberg, 2006). To provide a illustrative example, a study published on JAMA Surgery highlighted the case of Baptise Health System, a hospital in Texas that successfully negotiated bundled payment contracts for joint replacement surgeries. By using TDABC, the management gained a comprehensive understanding of all costs involved in such a sophisticated and complex surgery, allowing them to negotiate bundled payments that fully covered all incurred expenses, while increasing the quality of delivered care, and earning a profit on top of that (Navathe et al., 2017).

In addition to bundled payments, TDABC is highly valuable in the context of value-based payments to manufacturers. In these arrangements, pharmaceutical and medical device companies are reimbursed based on the outcomes their products deliver. In such scenarios, TDABC can provide the necessary depth of cost data to evaluate the cost-effectiveness of specific medications or devices, enabling informed decisions regarding reimbursement rates (Keel et al., 2017).

Moreover, TDABC assists in evaluating the cost-effectiveness of various treatments and interventions. For example, a healthcare system looking to expand its diabetes management program can use TDABC to compare the cost and effectiveness of different treatment approaches, such as medication management versus lifestyle interventions. This analysis can help healthcare organizations to take evidence-driven decisions that optimize both patient outcomes and resource allocation (Keel et al., 2017).

TDABC's role in healthcare goes well beyond cost measurement. It empowers organizations to define pricing strategies, negotiate bundled payment contracts, assess the cost-effectiveness of treatments, and participate in value-based payment arrangements. By providing a granular understanding of costs, TDABC equips healthcare providers with the insights needed to thrive profitably in a value-driven healthcare landscape.

4. The need for a comprehensive solution

4.1 The importance of cost containment in the healthcare industry

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.

4.2 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).

4.3. Proposed Solution

4.3.1. 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 (section 6), we provide an introduction of the two key technologies - RFID and Process Mining - that contribute to making our proposal highly innovative yet feasible. The concept and implications of FHIR will also be detailly explained in section 6.

4.3.2. 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.

4.3.2. 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.

5. 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.

5.1 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).

5.2. 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.

6. 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.

6.1 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 6.2.1 and 6.2.2, 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.

6.2 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.

6.2.1 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.

6.2.2 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 (section 6.5). In the next step, we integrate the collected data with the health information system in which the activities and patient data are recorded.

6.3 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.

As can be observed in the bellow figure 2, the process of collecting data is significantly seamless.

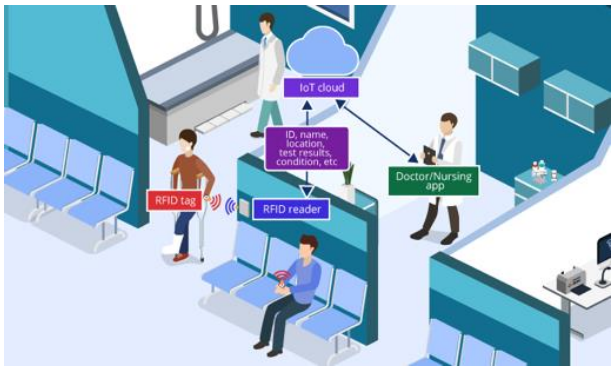

Figure 1: Smart Patient Tracking with RFID. Source by Shiklo, 2018.

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.

8. 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.

8.1 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.

8.2 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.

8.3 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.

8.4 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. (Its strategic disposition was previously mentioned in *chapter 6.2.2*). 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.

8.5 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.

8.6 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.

8.6.1 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.

8.6.2 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. (More details on our marketing and brand strategy are explained in *chapter 7.10*).

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 (extensive details provided on *chapter 7.11*). 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.

8.7 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 (outlined in *chapter 7.4*). 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.

8.9 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.

8.9.1 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.

8.9.2 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.

8.10 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.

8.12 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.

9. 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.

10. 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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12. 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