WELL-AI Platform: A SMART blockchain solution for eliminating bad medical debt

Inas Al Khatib, Malick Ndiaye

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Abstract

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Purpose: The purpose of this paper is to provide an overview of existing literature on patient medical debt, exploring its consequences, potential sources of humanitarian assistance, the usual procedures for managing patients with outstanding debt, and the investigation of technological platforms facilitating seamless connections between these entities. The objective is to identify any existing gaps in this process and assess whether a SMART blockchain solution could effectively bridge them.
Design/methodology/approach: Bridging the healthcare sector with humanitarian efforts to tackle medical debt presents a multifaceted worldwide dilemma demanding inventive approaches. A systematic analysis of literature utilizing the Scopus database and the PRISMA method was conducted, spanning from 1990 to 2024. Thematic analysis was then employed to organize the findings from the literature.
Findings: Despite the array of technological advancements aiding patients in locating resources for alleviating medical debt and its negative implications on both the patient and the hospital system as a whole, a singular, comprehensive blockchain solution with SMART capabilities is yet to emerge. This study advocates for the creation of such a solution to address this gap effectively.
Research limitations/implications: It was challenging to restrict the literature review solely to academic peer-reviewed journals of academic significance because of the technical multifaceted nature of the research subject.
Practical implications: Assist prospective researchers in establishing a research plan for upcoming investigations.
Social implications: Increases the importance of intensified research efforts that connect healthcare and humanitarian fields, with the goal of boosting the societal impact of such efforts on both the physical and mental health of individuals by eradicating medical debt.
Originality/value: A comprehensive review was conducted on a total of 358 papers spanning healthcare, humanitarian, and technology domains, resulting in the most extensive literature examination within these sectors. The review of 107 sources of which 62 were academic and 45 were professional, has introduced novel perspectives, offering fresh insights into prospective avenues for research within these fields.
Paper type: Systematic Literature Review

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Keywords: revenue cycle management, patient bad medical debt, SMART humanitarian platform, humanitarian assistance

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1. Introduction

Humanity's innate desire to lend a hand to others in need has long been the basis of humanitarian aid. While the contemporary form first appeared in the 19th and 20th centuries, ancient civilizations were not the first to provide relief during famines, wars, or other natural calamities [CITATION Gui \l 1033] [CITATION Hea17 \t \l 1033]. In *Ancient Times*, one of the earliest known legal codes, the Code of Hammurabi, had measures for aiding widows, orphans, and the impoverished. Systems for helping residents in need were in existence in ancient civilizations like the Greek and Roman ones [CITATION Mas24 \l 1033]. In *Middle Ages*, churches and monasteries in particular were important places for religious organizations to help the poor. To provide medical treatment for the ill and injured, organizations such as the Knights Hospitaller and the Order of Saint Lazarus were founded [CITATION Rod09 \l 1033]. In the *19th century*, Henry Dunant's establishment of the International Red Cross in 1863 was a crucial turning point in the formalization of humanitarian assistance. Due to Dunant's observations at the Battle of Solferino, when he saw injured troops suffer without receiving the care they needed, the Geneva Conventions and the Red Cross were established [CITATION ICR10 \l 1033]. In the *20th Century*, during and after World Wars I and II, humanitarian aid quickly grew. To meet the needs of those devastated by conflict, institutions such as the League of Nations, which was the

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Humanitarian aid has changed over time in both its character and extent. In order to offer emergency relief, development aid, protection, and advocacy for vulnerable communities impacted by disasters, a wide range of organizations, governments, non-governmental organizations, and individuals collaborate in humanitarian activities today. Humanitarian work continues to need adaptation and teamwork due to the complexity of situations such as natural disasters, poverty, displacement, and wars [CITATION Bai23 \l 1033]. It is therefore essential to comprehend the humanitarian environment in order to understand the ***technological innovation*** in aid. Saving lives and reducing physical and mental suffering is the main goal of humanitarian aid. The four humanitarian principles of *humanism, neutrality, impartiality, and independence* serve as the foundation for humanitarian work and direct the operations of humanitarian organizations. We are surrounded by technological innovation in humanitarian aid and assistance which is changing its operation through digitalization. The availability and use of mobile phones and social media by those impacted by humanitarian crises, the use of geospatial technologies and unmanned aerial vehicles (UAVs) to detect crises, the use of biometric identification to facilitate humanitarian assistance, and the shift to digital payments like e-vouchers and mobile money as relief provisions are just a few examples of how technology is fundamentally changing humanitarian assistance [CITATION EPR19 \l 1033].

The aim of this literature review is to explore the different phases of revenue cycle management within the healthcare sector and pinpoint the stage at which medical debt arises. It seeks to define medical debt and examine its impact on both patients and hospital systems. It aims to identify the technological advancements available to mitigate or manage unpaid medical bills. Furthermore, the research paper highlights an additional technological innovation such as ‘SMART (AI-powered) blockchain healthcare platforms’ whereby its distributed ledger technology that are powered by blockchain makes it easier to transmit patient medical information and medical bills securely, as one of its main benefits [CITATION Sam23 \l 1033]. In addition to allow patients with due medical bills to directly connect with registered humanitarian agencies, organizations, philanthropists on this platform in order to seek the needed aid to cover such debt that impact their wellbeing. Despite numerous studies exploring technological advancements in humanitarian aid and healthcare, existing literature identifies a gap where no technological innovation effectively bridges both sectors through a SMART blockchain platform. Therefore, constructing a conceptual framework for designing a solution called "WELL-AI," a SMART blockchain platform for managing medical debt and explore the technological aspects of such a platform is explored in this paper.

2. Research Methodology

A comprehensive examination and critical assessment of literature on medical debt and its implication on patients and hospital systems alongside the technological innovations that have been developed to resolve this global issue was performed through a systematic review. According to [CITATION Row04 \l 1033] these evaluations help in accessing information resources and assist in comprehending ideas, examining data, and interpreting outcomes related to a specific subject. [CITATION Seu12 \l 1033] offer practical advice on employing content analysis for literature reviews, consistent with the procedural framework outlined by [CITATION Seu05 \l 1033]. This framework, which we followed, encompasses four fundamental stages: 1) ***material collection 2) descriptive analysis 3) category selection 4) material evaluation to generate findings.***

Material Collection

The academic literature, published in academic database, between 1990 and 2024, in English were reviewed. Grey literature was reviewed and those are comprised of reliable news articles, industry magazines, web sites that are renowned and trusted in the information technology, humanitarian and healthcare industries. The search approach entailed choosing suitable keywords, like "healthcare medical bad debt," within the Scopus database to ascertain which country exhibited greater involvement in publications related to this subject. Utilizing the VOSviewer software, a bibliometric map was generated, revealing that China, the United Kingdom, and the United States were the primary countries concerned with healthcare medical debt. Notably, the United States emerged as the leading publisher, despite having a restricted number of publications on the topic as per this network visualization.

Figure 1: VOSviewer bibliometric map – healthcare medical bad debt

Scope of the Literature Review

The criteria for inclusion in our literature review is as follows:

- Our research was limited to ***empirical studies, book chapters and conference papers***

- On topics such as healthcare revenue cycle management, bad medical debt and its impact on patients and hospital systems, and SMART blockchain platforms
- Published since 2013
- Articles that are written in English were only included, because of the dominance of this language in the relevant literature

The exclusion criteria that were followed in the academic search:

- ***Lit reviews, conceptual papers, editorials*** are excluded
- Other industrial sectors excluded
- Publications before 2013 are excluded
- Other languages are excluded

Given the limited number of publications that the initial keyword yielded, the search was expanded by reviewing reference lists from the identified papers. Additional keywords were utilized for the Scopus Database search included "Revenue cycle management," "Healthcare Revenue cycle management," "Bad medical debt," "Impact of Bad medical debt," "Healthcare revenue cycle management platforms," "Designing SMART blockchain platform," and "Performance Assessment of SMART blockchain platform." Secondary research data collection for this review involved using the specified keywords in titles and abstracts within the Scopus databases. The existing literature was critically evaluated, and their findings were qualitatively synthesized to provide a comprehensive summary of evidence pertaining to the research question or problem. A thorough search was conducted to identify all relevant publications, facilitating systematic integration of the results and critical analysis of evidence related to the research topic. This rigorous material selection process resulted in **91** papers from which **61** academic sources being included in the study.

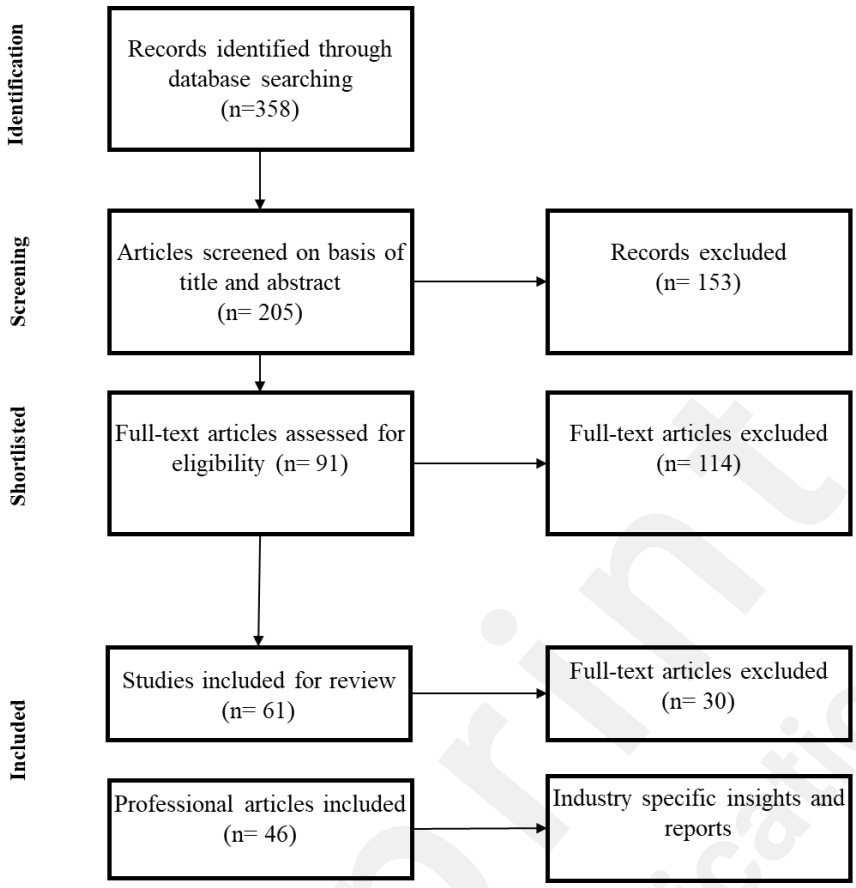

Figure 2. The systematic article selection process for this review

Information gathered was stored in a digital folder, and references were independently reviewed by the main author, who selected the final papers for analysis. Articles were assessed based on their relevance to the review's scope, with inclusion criteria defining characteristics necessary for paper selection and exclusion criteria disqualifying sources not aligned with the review's objectives or lacking empirical research or literature review. Given the topic's significance as a key industry trend, the search scope extended to **46** reliable industry sources and reputable newspapers (grey literature) to capture insights from subject matter experts. Additionally, renowned industry insight sources and corporate websites were consulted. This methodological approach aimed to identify the necessary sources to fulfill the literature aspect of designing a conceptual framework and developing components of a SMART blockchain platform.

Descriptive Analysis

The following section discusses data concerning the yearly distribution of papers, their allocation across different journals, and their origins by country. These findings are outlined to provide insights into publication patterns.

Category Selection

In this systematic literature review (SLR), the process of category selection played a pivotal role in organizing and

synthesizing the vast array of research findings within the particular field. Initially, we as researchers defined a clear scope and research questions to guide the selection of relevant categories. Those that this SLR provided answers to were:

R1: What are the various stages of revenue cycle management in healthcare?
R2: What is medical debt and its implication on patients and hospital systems?
R3: Which technological innovations support cover bad medical debt?
R4: Would a SMART healthcare blockchain platform be a useful tool to streamline the medical bad debt process in healthcare?
R5: Which framework design components and features should be considered as a baseline for developing a proposed SMART blockchain healthcare platform?

These categories have represented 11 key themes that were central to the research inquiries. Careful consideration is given to ensuring that the selected categories effectively captured the breadth and depth of the literature while avoiding redundancy or overlap. The categorization process involved iterative refinement, where initial categories were revised or merged based on emerging patterns and insights found during the literature review process. Ultimately, well-defined and thoughtfully selected categories serve as the foundation for structuring the synthesis of existing knowledge, enabling us to uncover meaningful patterns, trends, and gaps in the literature [CITATION Ver13 \l 1033].

Content Analysis

The standard method for studying texts will be content analysis, while thematic analysis is comparable to content analysis, it places more emphasis on the qualitative features of the studied material [CITATION Jofgy \l 1033]. We will first categorize the selected articles in terms of the publication characteristics such as the journal name, years, countries, research methods. Firstly, through mapping the literature and secondly, the findings will be thematically classified to fulfil the objectives of the research and provide answers to the research questions and reach the aim. Thematic analysis will be adopted by which the qualitative data identified from the literature will be looked into to find patterns in the meaning of the data in order to identify themes. An active process of reflexivity will be followed using subjective experience to make sense of the reviewed data. Furthermore, content analysis as a research tool will be implemented to determine the presence of those themes and find the relationships in the data yielded from the literature review [CITATION Hum22 \l 1033].

3. Systematic Literature Review Analysis Results

This portion offers an examination of the scholarly articles uncovered through this systematic literature review process.

Table 1: Academic Journals Included

Year	Journal	Country of Origin
1990	Economic Inquiry	United States
1994	International Review of the Red Cross - IRRC	Switzerland
1994	Journal of Business Venturing	United States
1995	Health Services Research	United States
1995	Software Quality Journal	Germany
1999	Journal of Engineering and Technology Management	United States
2001	Research in Engineering Design	Germany
2003	International Journal of Management Review	United Kingdom
2004	The Journal of General Internal Medicine (JGIM)	United States
2004	Journal of Product Innovation Management	United States
2009	Mediterranean Studies	United States
20	Journal of Computers	Hong Kong

09		
2009	Journal of Vascular Surgery	Netherlands
2010	International Journal of Operations & Production Management	United Kingdom
2011	Journal of Oral and Maxillofacial Surgery	Netherlands
2013	Environmental Health and Preventative Medicine	Germany
2014	International Journal of Product Development	United Kingdom
2015	IEEE Access	United States
2015	Turkish Journal of Emergency Medicine	Turkey
2015	Journal of the Association for Information Systems	United States
2016	British Journal of General Practice	United Kingdom
2017	Croatian Medical Journal	Croatia
2017	University of Pennsylvania Law Review	United States
2017	Journal of Systems and Software	United States

2018	MDPI Logistics	Switzerland
2019	The Journal of International Social Research	Turkey
2019	IEEE Transactions on Emerging Topics in Computing	United States
2019	MDPI Sustainability	Switzerland
2000	Technovation	United Kingdom
2020	Journal of Medical Internet Research	Canada
2020	MDPI Sustainability	Switzerland
2020	International Journal of Medical Informatics	Netherlands
2020	Long Range Planning	United Kingdom
2020	ETLA Working Papers	Finland
2021	Journal of Healthcare Leadership	New Zealand
2021	International Journal of Intelligent Networks	United Kingdom
20	Review of Accounting Studies	Germany

21		
2022	Production and Operations Management	United States
2022	BMC Health Services Research	United Kingdom
2022	Journal of AHIMA	United States
2022	Frontier Public Health	Switzerland
2022	MDPI Future Internet	Switzerland
2022	JAMIA Network Open	United States
2022	International Journal of Production Economics	Netherlands
2023	Oxford Research Encyclopedia of Politics	United Kingdom
2023	Front Public Health	Switzerland
2023	Healthcare (Basel)	Switzerland
2023	Blockchain in Healthcare Today	United States
2023	MDPI Cryptology	Switzerland

2023	PLOS Global Public Health	United States
2023	MDPI systems	Switzerland
2024	Elgar Encyclopedia of Crime and Criminal Justice	United Kingdom

Table 2: Conference Proceedings Included

Year	**Conference Name**	**Publisher**
2015	ACM 37th IEEE International Conference on Software Engineering	IEEE
2020	46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)	IEEE

Table 3: Book Chapters Included

Year	Book	Book Chapters	Publisher
2014	Revenue Cycle	Revenue Cycle. In: Medicine and Business	Springer Cham
2013	Improving Scheduling and Flow in Complex Outpatient Clinics	Handbook of Healthcare Operations Management: Methods and Applications	Springer Science
2018	Private Equity and Venture Capital in Europe - Markets, Techniques, and Deals	New Trends and Solutions in the Private Equity and Venture Capital Industry	Academic Press Inc.
2020	Revenue Cycle Management	The Business Basics of Building and Managing a Healthcare Practice	Springer, Cham
2021	SMACS (Social, Mobile, Analytics, Cloud and Security) Technologies for Business	SMACS Applications to Top Management	The ICFAI Foundation for Higher Education
2023	Standards and Evaluation of Healthcare Quality, Safety, and Person-Centered Care	Clinical Significance	StatPearls Publishing

Table 4: Academic Journals by Publishing Country

Country	Number of Academic Journals Included
Canada	1
Croatia	1
Finland	1
Germany	4
Hong Kong	1
Netherlands	4
New Zealand	1
Switzerland	10
Turkey	2
United Kingdom	10
United States	17
Grand Total	**52**

According to Figure 3, the leading countries in terms of publications on our topic are the United Kingdom, Switzerland, and the United States, with the latter taking the forefront in contributions.

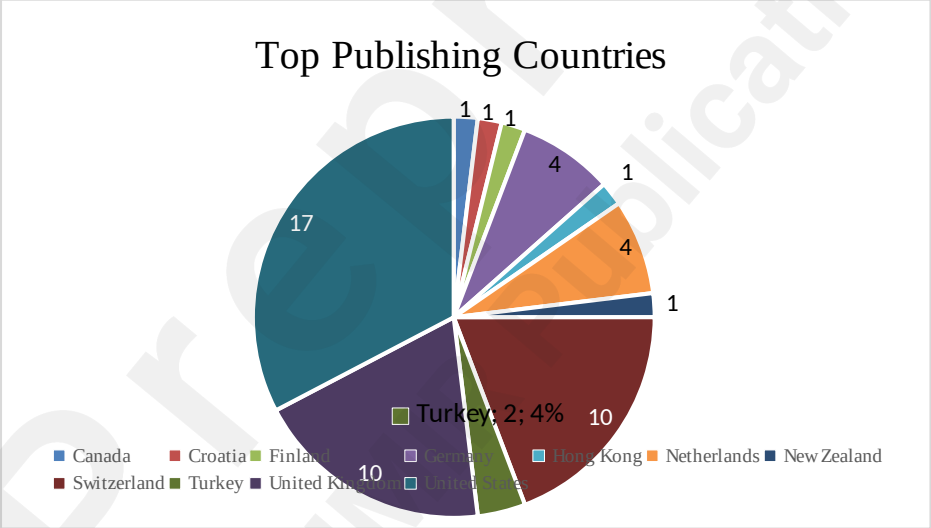

Figure 3: Top Publishing Countries

Table 5: Mapping Literature to Themes

Theme	Academic Papers	Grey Literature	Academic References (n=61)	Grey Literature References (n=46)
Theme 1: Humanitarian Aid	7	3	[CITATION Gui \l 1033] [CITATION Hea17 \t \l 1033] [CITATION Mas24 \l 1033] [CITATION Rod09 \l 1033] [CITATION YUR19 \l 1033] [CITATION Bok23 \l 1033] [CITATION Bai23 \l 1033]	[CITATION ICR10 \l 1033] **[CITATION EPR19 \l 1033]** [CITATION Mah23 \l 1033]
Theme 2: Revenue Cycle Management	17	19	[CITATION Sva17 \l 1033] [CITATION Bha21 \l 1033] [CITATION Zai23 \l 1033] [CITATION Soy13 \l 1033] [CITATION You231 \l 1033] [CITATION You221 \l 1033] [CITATION Cra13 \l 1033] [CITATION Che15 \l 1033] [CITATION Wil16 \l 1033] [CITATION Man11 \l 1033] [CITATION Mul22 \l 1033] [CITATION Chi09 \l 1033] [CITATION Min15 \l 1033] [CITATION Jew20 \l 1033] [CITATION Ron14 \l 1033] [CITATION Man09 \l 1033] [CITATION Pol22 \l 1033]	[CITATION Med23 \l 1033] [CITATION Rob11 \l 1033] [CITATION Bri \l 1033] [CITATION Cha17 \l 1033] [CITATION Kle23 \l 1033] [CITATION Phi20 \l 1033] [CITATION AHI22 \l 1033] [CITATION Nik21 \l 1033] [CITATION Bah16 \l 1033] [CITATION Med233 \l 1033] [CITATION Str23 \l 1033] [CITATION Ent23 \l 1033] [CITATION DrC23 \l 1033] [CITATION Jul23 \l 1033] [CITATION Hig22 \l 1033] [CITATION Rev23 \l 1033] [CITATION Roy23 \l 1033]

[CITATION Gle18 \l 1033]

[CITATION Bri18 \l 1033]

Theme 3: Blockchain Technology	10	2	[CITATION Gia23 \l 1033] [CITATION Hal21 \l 1033] [CITATION Amn22 \l 1033] [CITATION Eug19 \l 1033] [CITATION Tah23 \l 1033] [CITATION Gou22 \l 1033] [CITATION Sch22 \l 1033] [CITATION Jer17 \l 1033] [CITATION Vel20 \l 1033] [CITATION Abu20 \l 1033]	[CITATION RJK16 \l 1033] [CITATION Tim18 \l 1033]
Theme 4: Digital Platforms	6	4	[CITATION Abb19 \l 1033] [CITATION YVS21 \l 1033] [CITATION Bai22 \l 1033] [CITATION Ste18 \l 1033] [CITATION Zha20 \l 1033] [CITATION Muc20 \l 1033]	[CITATION Ste20 \l 1033] [CITATION CRS22 \l 1033] [CITATION IBM23 \l 1033] [CITATION Jul21 \l 1033]
Theme 5: Artificial Intelligence Use in Digital Platform	1	1	[CITATION Muc20 \l 1033]	[CITATION Pet19 \l 1033]
Theme 6: Implications of Medical Debt	3	7	[CITATION Bec21 \l 1033] [CITATION Him22 \l 1033] [CITATION OTo04 \l 1033]	[CITATION Fac22 \l 1033] [CITATION Com23 \l 1033] [CITATION Mic22 \l 1033] [CITATION Per23 \l 1033] [CITATION Rex23 \l 1033] [CITATION The21 \l 1033] [CITATION Thi23 \l 1033]
Theme 7: Resources to cover	1	3	[CITATION Mak23 \l 1033]	[CITATION Def23 \l 1033] [CITATION CFP22 \l 1033] [CITATION RIP23 \l 1033

Medical Bad Debt				
Theme	**Academic Papers**	**Grey Literature**	**Academic References**	**Grey Literature References**
Theme 8: Standard Humanitarian Aid Matching Process	1	0	[CITATION Smi95 \l 1033] [CITATION Slo90 \l 1033]	
Theme 9: Technological Innovations to support cover Bad Medical Debt	0	6		[CITATION Cor23 \l 1033] [CITATION dot22 \l 1033] [CITATION PYM18 \l 1033] [CITATION Con23 \l 1033] [CITATION PYM18 \l 1033] [CITATION Rev22 \l 1033]
Theme 10: SMART blockchain Healthcare platform factors	3	0	[CITATION Cho20 \l 1033] [CITATION Dob18 \l 1033] [CITATION Gho23 \l 1033]	
Theme 11: Development of a SMART blockchain Healthcare platform	12	1	[CITATION Bha94 \l 1033] [CITATION Tat04 \l 1033] [CITATION Mün20 \l 1033] [CITATION Nih99 \l 1033] [CITATION Ric10 \l 1033]	[CITATION Jan96 \l 1033]

	[CITATION Ota17 \l 1033]
	[CITATION Muf00 \l 1033]
	[CITATION Sim01 \l 1033]
	[CITATION Har14 \l 1033]
	[CITATION Gou15 \l 1033]
	[CITATION Nig95 \l 1033]
	[CITATION Hol03 \l 1033]

According to Table 5, for the technological dimension of the researched topic, there is a requirement for reliance on grey literature. While from an academic publishing perspective, the emphasis lies on two primary themes: revenue cycle management and the development of a SMART blockchain Healthcare platform.

4. Systematic Literature Review Discussion

Humanitarian Aid

Humanity's innate desire to lend a hand to others in need has long been the basis of humanitarian aid. While the contemporary form first appeared in the 19th and 20th centuries, ancient civilizations were not the first to provide relief during famines, wars, or other natural calamities [CITATION Gui \l 1033] [CITATION Hea17 \t \l 1033]. In *Ancient Times*, one of the earliest known legal codes, the Code of Hammurabi, had measures for aiding widows, orphans, and the impoverished. Systems for helping residents in need were in existence in ancient civilizations like the Greek and Roman ones [CITATION Mas24 \l 1033]. In *Middle Ages*, churches and monasteries in particular were important places for religious organizations to help the poor. To provide medical treatment for the ill and injured, organizations such as the Knights Hospitaller and the Order of Saint Lazarus were founded [CITATION Rod09 \l 1033]. In the *19th century*, Henry Dunant's establishment of the International Red Cross in 1863 was a crucial turning point in the formalization of humanitarian assistance. Due to Dunant's observations at the Battle of Solferino, when he saw injured troops suffer without receiving the care they needed, the Geneva Conventions and the Red Cross were established [CITATION ICR10 \l 1033]. In the *20th Century*, during and after World Wars I and II, humanitarian aid quickly grew. To meet the needs of those devastated by conflict, institutions such as the League of Nations, which was the forerunner of the United Nations, and other relief organizations were founded [CITATION YUR19 \l 1033]. Following *World War II* with its founding in 1945, the United Nations placed a strong emphasis on the value of international collaboration in responding to humanitarian emergencies. To organize humanitarian operations worldwide, the UN established the Office for the Coordination of Humanitarian Affairs (OCHA) [CITATION Bok23 \l 1033]. From the *late 20th century to the present*, in response to complicated catastrophes, natural disasters, and wars throughout the world, humanitarian activities have grown. NGOs, or non-governmental organizations, like Oxfam, CARE, and Médecins Sans Frontières (Doctors Without Borders) became important actors in the relief and advocacy fields [CITATION Mah23 \l 1033].

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Healthcare Revenue Cycle Management

Wholeness is a representation of the holistic idea of health. Being in a condition of health allows one to express their full potential within their living environment and to perform successfully on a physical, mental, social, and spiritual level. Each person is situated on a graded scale or continuous spectrum (continuum) that ranges from wellness and optimal functioning in every element of one's life, at one end, to sickness resulting in death, at the other. Health and illness are both dynamic processes [CITATION Sva17 \l 1033]. In healthcare, the key stages along a patient journey to ensure a person remains healthy typically includes awareness, screening, diagnosis, treatment, adherence, and control or remission [CITATION Bha21 \l 1033]. Figure 4 illustrates links those treatment planning stages alongside the patient access activities with the

entirety of the revenue cycle management cycle processes that are critical to ensure the expenses endured throughout every stage is covered and the healthcare provider remains financially healthy. However, should there be any outstanding medical expense (in the AR management stage) and in the scenario a patient is unable to cover it this is deemed as a bad medical debt which humanitarian aid and assistance would be essential to ensure the wellbeing of a recovering patient. The need for eliminating health debt that negatively impacts the quality of life and destresses mental health of not only the patient but the entirety of their family members. This is a worldwide issue.

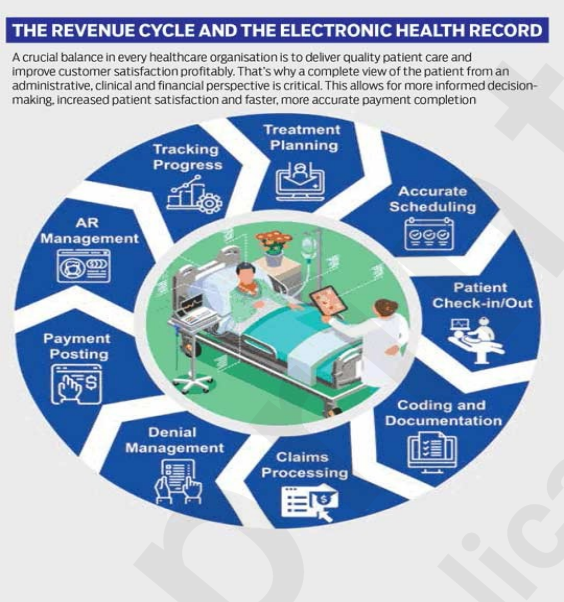

Figure 4: Revenue Cycle Management Cycle

Treatment Planning

In revenue cycle management, treatment planning is the process of listing and arranging the medical services a patient needs. It entails figuring out what treatments, examinations, drugs, and other services are required to meet a patient's medical requirements. This strategy is necessary for both the effective management of the revenue cycle and the patient's treatment. Treatment planning aids in the estimation of the expenses related to the patient's treatment. This covers the cost of treatments, prescription drugs, doctor visits, and other charges. Comprehending these expenses facilitates the creation of precise invoices and financial agreements [CITATION Zai23 \l 1033]. In order to ensure that the scheduled operations and services are covered by insurance, treatment planning is helpful in insurance verification. It lowers the possibility of claim denials by guaranteeing that the therapies are in line with the patient's insurance plan's coverage. Careful planning of the course of therapy guarantees that medical codes appropriately reflect the services rendered. Precise coding is essential for payment and guards against billing mistakes that might cause delays or rejection of claims [CITATION Med23 \l 1033]. Healthcare providers can forecast the expected income associated with a patient's care by providing an outline of the planned treatments and services. This facilitates planning and budgetary forecasting [CITATION Soy13 \l 1033]. Communicating with the patient about the suggested therapies is a part of treatment planning. Informed permission may be obtained and billing-related misunderstandings and conflicts can be minimized with clear communication about the scheduled procedures, related expenses, and available payment alternatives [CITATION Rob11 \l 1033]. In the healthcare industry, treatment planning guarantees adherence to standards of compliance and regulatory requirements. It assists in adhering to the required procedures and policies for invoicing and treatments, reducing the possibility of noncompliance [CITATION Bri \l 1033]. In general, treatment planning is essential to revenue cycle management

because it guarantees that the care given is in line with the patient's needs, insurance coverage, and financial considerations. This makes it easier to bill and collect money for medical services in an efficient manner [CITATION You231 \l 1033].

Accurate Scheduling

The process of effectively planning and managing appointments, treatments, and services inside a healthcare institution or practice is referred to as accurate scheduling in revenue cycle management. In order to optimize income and efficiency, it entails making sure that appointments are planned correctly, connecting patients with the appropriate practitioner, and maximizing resource use. By optimizing resource usage and reducing idle time, effective scheduling aids in the management of resources including personnel, facilities, and equipment [CITATION You221 \l 1033]. In revenue cycle management, precise scheduling is essential to ensure that visits and treatments for patients are adequately scheduled into providers' calendars, with as few gaps as possible that might result in underutilization of resources; therefore, maximizing provider time [CITATION Cra13 \l 1033]. Putting methods into place to reduce missed appointments (no shows) and cancellations, which can have an effect on workflow efficiency and revenue creation [CITATION Cha17 \l 1033]. Furthermore, accurate scheduling improves patient flow and Reduces wait times, increasing patient satisfaction, and guaranteeing a seamless patient flow across the medical institution. Precise scheduling guarantees that treatments and services are suitably recorded and paid for, lowering the possibility of mistakes that might jeopardize income and reimbursements [CITATION Che15 \l 1033]. All things considered, precise scheduling is an essential part of revenue cycle management in the healthcare industry, having an effect on both the financial health of a facility or practice and the standard of patient care.

Patient Check-in / Check-out

"Patient Check-in / Check-out" in revenue cycle management describes the procedure of registering and concluding a patient's visit within a medical institution. These actions have a direct bearing on the healthcare organization's finances, making them essential components of the revenue cycle. ***Patient check-in*** is the process a patient goes through when they first come to the hospital. The staff updates the patient's records, confirms insurance coverage, and gathers vital demographic and insurance information at check-in. Precise data gathering at this point guarantees that the rendered services may be appropriately invoiced and paid for [CITATION Wil16 \l 1033]. ***Patient check-out*** is the stage takes place at the end of the patient's appointment. Upon completion of the visit, the administrative staff or healthcare practitioner updates any information that was not previously collected, examines the services provided, and creates the paperwork that will be needed for billing. Accurately documenting the rendered services and starting the invoicing procedure depend on this step [CITATION Man11 \l 1033].

For revenue cycle management, efficient check-in and check-out procedures are essential since they can reduce mistakes given that precise patient data obtained at check-in helps to guarantee accurate billing and reimbursement by reducing billing mistakes. Accurately recorded services at the time of check-out expedite the billing cycle, resulting in speedier payment for the medical services rendered i.e. quick reimbursement. Simplified procedures for checking patients in and out help patients have a more positive experience by cutting down on wait times and making sure that paperwork doesn't take undue time away from their visit; hence, increases patient satisfaction. In general, a healthcare organization's revenue cycle depends on the efficient administration of the patient check-in and check-out procedures, which has an effect on patient

happiness, billing accuracy, and reimbursement [CITATION Kle23 \l 1033].

Coding and Documentation

In the healthcare sector, coding and documentation are essential components of revenue cycle management; ***Precise Coding*** in terms of converting the services provided to a patient into universal medical codes requires accurate coding. Certain procedures, diagnoses, treatments, and services rendered during a patient's visit are represented by these codes (such as CPT and ICD-10). Precise coding guarantees that medical services are correctly invoiced and paid for by government or insurance payers [CITATION Phi20 \l 1033]. While ***Documentation***, supports the codes assigned to each patient interaction, healthcare practitioners must produce thorough and in-depth documentation. The patient's medical history, examination findings, test results, diagnoses, therapies, and other relevant data are all included in thorough documentation. The codes presented for billing are supported by comprehensive and accurate documentation that demonstrates the necessity and completeness of the services rendered [CITATION Mul22 \l 1033]. Proper paperwork and accurate coding are essential for efficient billing and reimbursement. The effectiveness of the revenue cycle may be impacted by inaccurate or insufficient coding or documentation, which may result in claim denials, postponed payments, or even legal problems [CITATION Chi09 \l 1033].

Moreover, adherence to healthcare legislation and standards is ensured by appropriate documentation and coding processes. Regulatory agencies have established standards and coding criteria that healthcare institutions must follow. Frequent audits evaluate the correctness and adherence to coding and documentation standards; in the event that deficiencies are discovered, revenue cycles may be impacted by penalties, fines, or reimbursement clawbacks [CITATION AHI22 \l 1033]. Additionally, the sound financial standing of a healthcare company is influenced by effective coding and documentation procedures. Services that are precisely categorized and properly documented lead to fast and accurate reimbursements, which improve cash flow and decrease inefficiencies in the revenue cycle [CITATION Min15 \l 1033]. In conclusion, there is a critical link between revenue cycle management, documentation, and code. For successful billing, compliance, financial performance, and the general effectiveness of a healthcare organization's revenue cycle, accurate coding backed by thorough documentation is essential [CITATION Jew20 \l 1033].

Claims Processing

In the healthcare sector, claims processing is a crucial component of revenue cycle management. It entails the filing, evaluation, and payment of medical claims for the services that healthcare practitioners offer to patients [CITATION Ron14 \l 1033]. The process can be explained as first a patient visits a provider (hospital, clinic, etc.) to obtain medical care. Following the provision of care, the healthcare provider drafts a claim that contains information on the patient, the services (medication, treatments, procedures), and the healthcare provider. The prepared claim is thereafter sent for payment to the appropriate payer or insurance provider. Depending on the provider and payer systems, this can be done manually using paper forms or electronically using defined formats. The payer or insurance provider examines the claim to make sure it satisfies the requirements for payment. They confirm that the patient is covered, that the services are rendered, and that the rules for coding and invoicing are followed. Following examination, the payer decides whether to pay the claim or not. The healthcare provider is paid for the services they give if their application is accepted. In most cases, the provider is given

the opportunity to remedy any errors and resubmit the claim if it is refused. Upon approval of the claim, the payment is posted to the patient's account, and the patient may be invoiced for any amount that remains after insurance coverage [CITATION Man09 \l 1033]. Since claims processing has an effect on healthcare companies' cash flow, it is essential for revenue cycle management. The provider's financial stability may be impacted by claims processing delays or rejections, which might result in postponed payments and higher administrative expenses. In order to guarantee accuracy in coding and documentation, expedite the claims process, and reduce the number of claims denials or rejections, providers frequently use specialist software or depend on outside billing services [CITATION Nik21 \l 1033].

Denial Management

Within the context of revenue cycle management (RCM), denial management is the act of locating, resolving, and minimizing insurance company or payer claim denials. Insurance companies frequently reject or partially reject claims from healthcare providers when they submit them for payment for a variety of reasons, including missing information, incorrectly coded claims, a lack of pre-authorization, or non-covered services [CITATION Pol22 \l 1033]. Several crucial phases are involved in denial management, starting from the ***Identification of Denials***, whereby in this phase entails keeping a tight eye on any incoming payment rejections. It can involve keeping tabs on the causes of rejections, how often they occur, and how much money is involved in each kind of denial. Followed by ***Analysis and Root Cause Identification***, as it is critical to comprehend the reasons behind claim denials. To find recurring causes for denials, it might entail pattern analysis. For example, it can be the result of coding mistakes, incomplete paperwork, or problems with the patient's coverage or eligibility. Subsequently, ***Resolution and Resubmission***, after determining the underlying source of the problem, the appropriate steps are followed to address it. It can entail getting further information, resolving coding or paperwork issues, or appealing the refusal in accordance with the payer's particular guidelines. The objective is to resolve the matter and immediately and correctly resubmit the claim. Finally, ***Process Improvement***, the process of managing denials is continuous. In order to avoid reoccurring problems, providers frequently make modifications to their workflows, coding standards, or documentation guidelines in response to the reasons for denials that were found [CITATION Med231 \l 1033]. Reducing rejections is necessary to keep the revenue cycle in good shape. It guarantees that healthcare professionals are paid for their services in a timely and correct manner. A well-managed denial process may enhance cash flow, lower rework-related administrative expenses, and enhance the revenue cycle as a whole [CITATION Bah16 \l 1033].

Payment Posting

An essential part of revenue cycle management (RCM) is payment posting. It is the procedure for documenting and balancing payments that healthcare providers get for their services from clients, insurance providers, or other payers [CITATION Med232 \l 1033]. Payment posting is important in the larger context of RCM in a number of ways. Correct payment posting guarantees that the money received for provided healthcare services is appropriately documented. It supports the financial stability of the healthcare organization by aiding in the tracking and acknowledgment of money received (revenue recognition) [CITATION Med233 \l 1033]. Posting payments entails reconciliating received funds with related services or invoices. By guaranteeing that payments are appropriately attributed to the appropriate accounts or invoices, it minimizes inconsistencies and guarantees the accuracy of the financial documentation [CITATION Str23 \l

1033]. Payment posting allows for the quick identification and resolution of any anomalies or problems with payments, including underpayments, overpayments, and rejected claims. This aids in the settlement of billing disputes and guarantees that the healthcare provider gets all of the money they are due [CITATION Ent23 \l 1033]. To produce financial reports and carry out analysis, accurate payment posting data is necessary. Healthcare firms may use the insights it offers on revenue cycle performance to pinpoint areas for improvement, streamline procedures, and improve financial results [CITATION Ent231 \l 1033]. In conclusion, payment posting is essential to the revenue cycle because it guarantees accurate recording, reconciliation, and analysis of payments received for services delivered, all of which have a direct influence on the financial stability of healthcare providers [CITATION DrC23 \l 1033].

Accounts Receivable (AR) Management

A key element of revenue cycle management (RCM) is Accounts Receivable (AR) management. The whole process of earning money for a company, from the first contact with a client to the receipt of payment, is referred to as the revenue cycle. In particular, AR management pertains to the administration and oversight of delinquent payments that a business's clients or customers owe it. AR management is crucial to ensure that money due to a business is collected effectively and on time within the framework of the revenue cycle [CITATION Jul23 \l 1033]. Usually, the Accounts Receivable (AR) Management procedure entails creating and sending bills to clients for the products or services provided is known as invoicing. Followed by monitoring and tracking, keeping tabs on past-due bills and unpaid balances. While, payment processing comes next as the act of collecting and handling money from clients via a variety of methods (credit card, cheques, electronic transfers, etc.). Lastly. follow-up and Collections: Reminding clients when payments are past due, following up with them, and starting the collection procedure if required [CITATION Hig22 \l 1033]. The cash flow and general financial health of a corporation are strongly impacted by effective AR management. Effective management of AR guarantees timely revenue collection, lowering the risk of bad debts and enhancing the company's liquidity. This streamlines the flow of money into the company, which in turn improves the revenue cycle's overall efficiency. Thus, as AR management is primarily concerned with maximizing the collection of money due to the business, it is an essential component of revenue cycle management and helps ensure that the whole revenue generating process runs smoothly [CITATION Rev23 \l 1033].

Tracking Progress

Progress monitoring is closely related to revenue cycle management (RCM). In healthcare companies, RCM entails supervising the whole claim, payment, and revenue creation process. In this cycle, progress monitoring is essential because it makes sure that every step is tracked, evaluated, and optimized for effectiveness, precision, and financial success [CITATION Roy23 \l 1033]. Progress tracking assists in keeping track of the state of claims from submission to payment. It entails monitoring claims that are being handled, refused, or are pending. Organizations may find bottlenecks, take quick action on problems, and guarantee on-time payment by monitoring this progress. Monitoring revenue sources, seeing trends, and examining financial data are all part of keeping tabs on how revenue generating is going. This aids in identifying revenue streams, projecting earnings, and refining tactics to increase revenue production. RCM measures success using a range of performance indicators. Key performance metrics such as days in accounts receivable, collection rates, rejection rates, and so forth are monitored as part of progress tracking. By examining these measures, one may

pinpoint areas in need of development and put plans into action to boost income collection. Ongoing assessment of RCM procedures is made possible by regular progress monitoring. It enhances the revenue cycle overall by assisting in the identification of inefficiencies, the use of best practices, and the adaptation to changes in technology or legislation. RCM is subject to compliance requirements and healthcare legislation. By monitoring progress, you can be confident that the procedures follow these guidelines, reducing risks and guaranteeing legal and regulatory compliance [CITATION Gle18 \l 1033]. Progress tracking is essentially about ongoing analysis, optimization, and monitoring within revenue cycle management. Healthcare companies must optimize their income, reduce rejections, simplify their operations, and maintain financial stability [CITATION Bri18 \l 1033]. Derived by this background on the adoption of a SMART healthcare blockchain platforms to eliminate the medical bad debt at the ***Account Receivable (AR) Management*** stage of this cycle.

Blockchain Technology

Blockchain is a new technology that is being used to provide creative solutions across many industries, including the medical field. A blockchain network is utilized by hospitals, labs, pharmacies, doctors, and other healthcare providers to store and share patient data [CITATION Gia23 \l 1033]. Blockchain-based software can reliably detect serious errors, including potentially harmful ones, in the medical domain. As a result, it can enhance the efficiency, security, and openness of medical data exchange within the healthcare system. Medical facilities can improve the analysis of medical information and obtain new insights with the use of this technology. We examined Blockchain technology in this study and offers noteworthy advantages in the field of healthcare, including increased data efficiency. It facilitates a distinct data storage pattern at the greatest degree of security and can help allay concerns about data tampering in the healthcare industry. It offers adaptability, connectivity, responsibility, and data access authentication. Health records must be kept private and secure for several reasons. Blockchain helps prevent certain dangers and supports decentralized data protection in the healthcare industry [CITATION Hal21 \l 1033].

Blockchain is fundamentally a distributed system that keeps track of and records transactions. In more precise terms, blockchain is an immutable, shared record of peer-to-peer transactions that is kept in a digital ledger and constructed from connected transaction blocks. Without requiring prior trust between the participants, blockchain relies on well-established cryptographic techniques to enable each member of a network to communicate (e.g., store, trade, and view information). Transaction records are kept and dispersed among all network users in a blockchain system, which lacks a central authority. All users of the network may identify interactions with the blockchain, which records an unchangeable audit trail of all interactions and requires network verification before information is added. This allows for trustless collaboration among users of the network [CITATION RJK16 \l 1033]. ***This technology is essential to ensure the authenticity of the medical records and bills patients are asking to be covered through humanitarian assistance.***

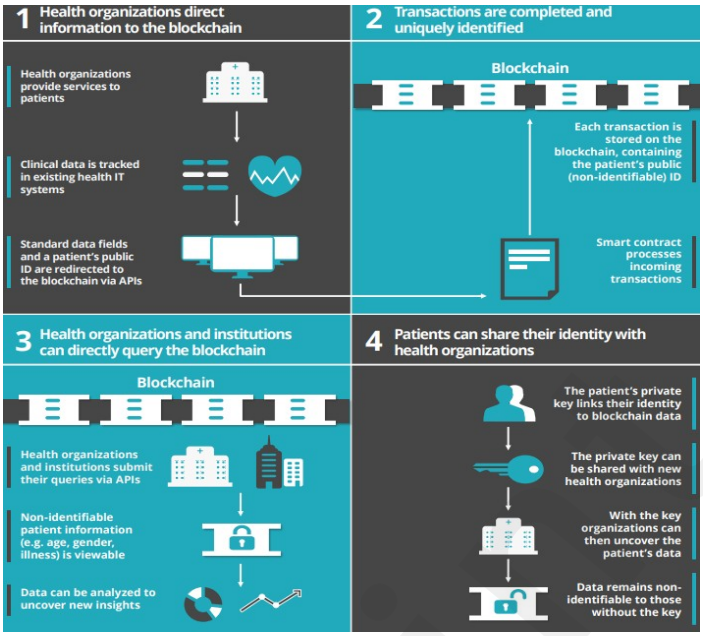

Figure 5: Illustrative Healthcare Blockchain System [CITATION RJK16 \l 1033]

Blockchain technology provides openness, security, and immutability to the data, which may be very helpful in confirming and authenticating medical records or bills [CITATION Amn22 \l 1033]. Starting with ***Immutable Record Keeping*** as blockchain keeps an immutable record, meaning that once information is entered, it cannot be changed backward without the agreement of other network users. The integrity of medical records kept on a blockchain would be guaranteed by its immutability [CITATION Eug19 \l 1033]. Secondly, ***Data Security and Encryption***, on the blockchain, patient data may be safely kept and protected. Private keys and access restrictions can be used to guarantee that only people with permission such as patients or medical professionals can access particular documents [CITATION Tah23 \l 1033]. Thirdly, ***Traceability and clear audit trails*** are made possible by the ability to trace each transaction and modification made to a medical record or bill. This functionality can assist in identifying any illegal modifications and improve accountability [CITATION Gou22 \l 1033]. Fourthly, ***Interoperability and Data Sharing***: While preserving data integrity, blockchain technology can enable safe exchange of medical records across healthcare providers. Patients might designate temporary access as needed and manage who gets access to their information [CITATION Sch22 \l 1033]. Fifthly, ***Billing and Payment Process Automation*** as smart contracts, which are self-executing agreements with terms encoded directly into the code, have the ability to automate certain billing procedures. Payments can be made automatically when certain criteria are satisfied (such as the conclusion of a medical service), which simplifies billing and lowers mistake rates [CITATION Jer17 \l 1033]. Sixthly, ***Consent Management*** as blockchain technology has the ability to handle patient permission for data sharing. To improve privacy, patients can provide detailed permissions for particular categories of data or time periods [CITATION Vel20 \l 1033]. Lastly, ***Reduced Fraud***, since every transaction on the blockchain is traceable and transparent, it can help cut down on instances of fraudulent billing and claims because every transaction is viewable to authorized parties [CITATION Tim18 \l 1033].
Nevertheless, there remain obstacles to blockchain adoption in the healthcare industry, including scalability, regulatory compliance, data privacy, and integration with current systems. Furthermore, even though blockchain technology can safeguard network data, early data breaches can still be avoided by securing endpoints, or the locations where data is input, and by properly onboarding data into the blockchain. The use of blockchain technology can greatly increase the security and veracity of medical bills and data, but its deployment calls for thorough thinking out of these issues and a well-thought-out plan [CITATION Abu20 \l 1033].

Digital Platforms

Digital platforms are online venues or frameworks that help people connect, communicate, and transact with one other; these exchanges are frequently made possible by technology. These platforms may be used for a variety of things, such as content sharing, service delivery, social networking, and online shopping [CITATION Ste20 \l 1033]. These are a few typical kinds such as ***social media platforms***, these let people interact with one other, exchange material, make profiles, and

have conversations. Facebook, Twitter, Instagram, LinkedIn, and TikTok are a few examples [CITATION Abb19 \l 1033]. Secondly, ***e-commerce platforms***, these enable the online purchase and sale of products and services. Amazon, eBay, Alibaba, Shopify, and Etsy are a few examples [CITATION CRS22 \l 1033]. Thirdly, ***websites or programs*** that allow users to submit, share, and view different kinds of information, such as textual content (Medium, WordPress), photos (Flickr, Imgur), and videos (YouTube), are known as content-sharing platforms [CITATION YVS21 \l 1033]. Fourthly, ***On-Demand Service Platforms***, these link clients looking for certain services with service providers. Uber, Airbnb, TaskRabbit, and DoorDash are a few examples [CITATION Bai22 \l 1033]. Fifthly, ***Cloud Computing Platforms***, they provide customers with remote access to infrastructure, storage, and computing resources over the internet. Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform are a few examples [CITATION IBM23 \l 1033]. Sixthly, ***Crowdfunding Platforms*** are online platforms that let people or companies collect money from a big number of donors for various projects or causes. GoFundMe, Indiegogo, and Kickstarter are a few examples [CITATION Ste18 \l 1033]. Finally, ***Online learning platforms***, these are websites that provide tutorials, courses, or other educational resources. Coursera, Udemy, Khan Academy, and Duolingo are a few examples [CITATION Jul21 \l 1033]. The features, target markets, and goals of these platforms differ greatly. To run effectively, they frequently rely on digital infrastructure, data analytics, and user-generated content. They have also revolutionized a number of sectors, opening up new avenues for international trade, communication, and cooperation [CITATION Zha20 \l 1033].

Over time, a growing number of technologies have been identified as being ready to form the foundation of a digital platform. Product platforms gave rise to digital platforms in their own right. Microprocessors were the first platforms to move toward digitalization, despite the fact that both are different types of platforms. Digital platforms known as operating system (OS) platforms include, most notably, PC and mobile OSs. Digital platforms have arisen without explicit OS connectivity, the interactions between users of the platform form its heart, generating value even in the absence of direct ownership of tangible assets or product sales. Additionally, OS-type platforms have grown by becoming platforms in and of themselves, incorporating adjunct layers (new middleware) and modules from the technological stack. This layer is being included into mobile and PC operating systems. All things considered, such platforms provide new, rich technical features and boundary resources, which not only generate enormous volumes of data appropriate for AI algorithms but also serve as entrance points for the use of AI [CITATION Muc20 \l 1033].

Artificial Intelligence Use in Digital Platforms

These technologies were but one tool in the AI toolkit when it came to digital platforms. AI applications may be used to complete very tiny percentages of operations, yet even in those cases, there may be observable commercial benefits. Workloads and applications using AI are getting more and bigger all the time. In specific, machine learning was applied. Large-scale AI applications like these have pushed machine learning to a prominent position in the application portfolio. AI's function has evolved from being one of the many little building elements of platform technology to being both a platform unto itself and a significant layer in the stack. Digital platform company operations heavily rely on AI technology and platforms. AI platforms are more than just stand-alone AI technologies; while they may be thought of as tools for developing additional platforms. They extend not just throughout apps but also in a vertical direction between end users and the hardware infrastructure [CITATION Muc20 \l 1033].

Businesses are well aware of artificial intelligence's (AI) potential, despite the fact that AI is still in its infancy and will become much more potent in the future, executives find it impossible to let go of the notion that they should have applications for it and be using it effectively now. An example of a modern usage of artificial intelligence (AI) for business: are digital platforms. The shift that organizations are experiencing in their approach to digital transformation is best understood in terms of their shift from process focus to platform orientation. They are taking many various approaches to this, but one of their main strategies is to create platforms. Through platforms, they may transform the customer experience and delight their consumers. Alternately, they create systems that enhance employee satisfaction and enable them to adapt and react to regulatory changes more effectively. The easy part is the technology. Platform user acceptance is the most challenging aspect. The platform cannot flourish unless the stakeholder groups embrace it. The stakeholders must be willing and desirous of using the platform. They have to desire to do it; no amount of message or change management will make it happen. If they benefit from the platform, it is the only way they will want to utilize it. They are drawn to the platform's experience. Three characteristics determine the effectiveness of a digital platform's design: A) the platform must anticipate the demands of the user; C) the platform must then provide the user with transactions that offer a comprehensive experience; T) the platform transaction has to promptly meet the user's demands as well. To encourage user adoption, these three qualities which are essential building blocks of excellent user experiences must coincide on the platform. For the user to be delighted with the experience, the platform must deliver [CITATION Pet19 \l 1033].

Consequently, the study proposes a framework that connects the healthcare field and humanitarian aid field to address a universal issue of supporting patients cover their medical expenses or so known as bad debt. For that purpose, Elsevier Scopus database of peer-reviewed literature was used as the primary source of research conducted in the fields of *blockchain technology, digitalization of humanitarian aid, medical bad debt, and artificial intelligence* which were reviewed and analyzed. This database is selected as it is built on the broadest range of reliable, high-quality, interdisciplinary research and scholarly literature in the fields of humanitarian aid, engineering, artificial intelligence applications, health sciences, and technology. However, due to the developing nature of this technological topic, industry insights and reports, technical blog expert opinions and case studies were also used and not only peer reviewed journals.

Medical Debt

Figure 6 is an illustration of the amount of patient revenues produced that a hospital does not anticipate realizing, bad debt (an expenditure account) is an ex-ante evaluation of account collectability (i.e., current period service billings that will not materialize into future cash inflows). Therefore, the non-collection of money from patients who the hospital is expected to pay for services rendered - is the root cause of bad debt write-offs. These sums cover the whole cost for self-paying uninsured patients as well as the "patient portion" (deductibles and coinsurance) of bills from insured patients. Therefore, substantial bad debt expenses might be seen by creditors as proof of inadequate ex post collection attempts, mishandled hospital policies, or a general lack of confidence about revenue collectability [CITATION Bec21 \l 1033].

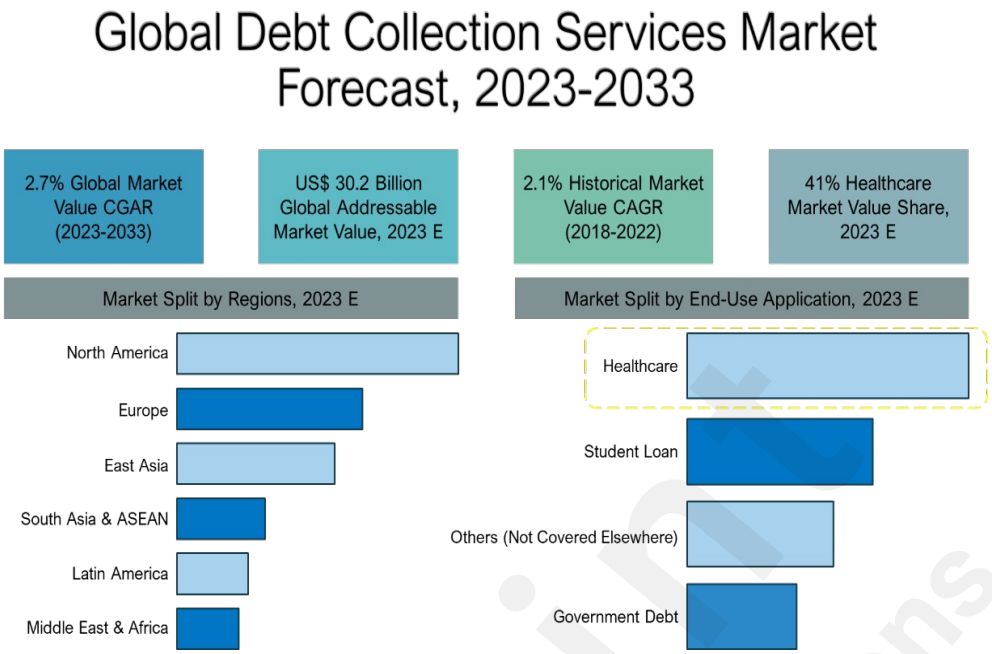

Figure 6: Global Debt Collection Services Market Forecast 2023-2033 [CITATION Fac22 \l 1033]

Implication of Medical Debt on the patient

Bad debt is unpaid medical costs that a hospital has attempted but been unable to collect. Bad debt is the term used to describe debt owing by patients who are not eligible for financial aid since hospitals are generally not allowed to pursue collections on invoices that qualify for charity treatment or financial assistance [CITATION Com23 \l 1033]. When a patient's current income or resources are insufficient to cover their medical expenses, they may utilize credit cards, loans, or mortgages to make the payments, work out a payment plan with hospitals and healthcare providers, or choose not to pay the bills at all. Debt may harm one's physical and emotional well-being, appear to prevent one from seeking care later on, and some have even suggested that debt is a social determinant of health (SDOH).

According to recent surveys, the bulk of outstanding debts on people's credit records are late medical bills. But those studies' dependence on the little data from credit reports prevented them from analyzing medical debts that are not past due or that are supported by loans, credit cards, or mortgages; they also couldn't examine the personal traits of the borrowers or the long-term effects of their debts. In the US market, nearly one-fifth of US households many of whom have relatively adequate health insurance and middle-class incomes had debt related to medical expenses. These debts seem to jeopardize the security of shelter and food, which might have an impact on the borrowers' long-term health. By improving their financial help programs and being patient while collecting debts, hospitals and clinics may be able to lessen these issues. It may also be helpful for clinicians to screen for unfavorable social determinants of health (SDOHs) and provide the right recommendations. Nevertheless, the efforts of physicians cannot take the place of changing policy. Reducing medical debt could be aided by expanding Medicaid nationwide. In order to eradicate medical debt, universal coverage that removes onerous out-of-pocket expenses must be put in place [CITATION Him22 \l 1033].

The financial security of a person or a family is significantly impacted by medical debt. It makes trade-offs between paying off debt and acquiring other necessities for managing daily expenses and accumulating wealth. This includes paying for school, investing in job progression, saving money, and eliminating or paying off other obligations, such as credit card debt, in addition to other living expenses like food and shelter. Some people manage their debt with the aid of commendable existing tactics, such halting litigation, negotiating repayment conditions, charity buy-outs of debt, and even deleting medical debt from credit records [CITATION Mic22 \l 1033]. Yet, what if all of such existing strategies fail, an alternative resolution such as humanitarian assistance would be their alternative as medical debt negatively impact patients since the feel trapped and are experiencing depression and shame (negative mental health implications) because of it while others filed for bankruptcy [CITATION Per23 \l 1033].

A large portion of medical debt is either sold or assigned to outside debt collection companies, who frequently make aggressive attempts to collect the bill, causing anxiety for the patients. Hospitals and debt collectors have been able to place liens on patients' homes or take money right out of their paychecks thanks to judgments they have won against patients. Patients have occasionally also lost their houses. A patient's credit score may be negatively impacted by medical debt [CITATION Com23 \l 1033]. Aggressive debt recovery for medical treatment is applied indiscriminately and has a detrimental impact on people who are least able to navigate the health system from obtaining health care in the future [CITATION OTo04 \l 1033].

Implication of Medical Debt on the hospital system

Bad debt is commonly incurred by healthcare systems and providers because of mistakes made in the coding, registration, and billing processes, such as neglecting to check the insurance of a patient before a procedure that has large out-of-pocket expenses that people with inadequate or no insurance cannot afford. Moreover, misconceptions regarding the benefits that insurance will cover, restricted provider networks or, possibilities unforeseen medical occurrences ineligible for charity care programs or unaware of them by patients [CITATION Rex23 \l 1033].

Medical debt has a detrimental effect on people's ability to get and use necessary healthcare, both personally and collectively. Compared to those without debt, persons with debt including medical debt are less likely to be able to afford necessary medical treatment or prescription drugs. Some possible explanations include providers refusing to offer service until past-due payments are paid or a reluctance to take on further debt. The financial stability of nearby healthcare providers may be threatened by the bad debt that results from medical debt. The majority of hospitals that close do so due to budgetary issues. Many factors contribute to financial difficulties, but high rates of uncompensated care and bad debt can strain hospital finances, especially for rural facilities that deal with a variety of other unfavorable factors in addition to a less lucrative payer mix (e.g. demographics, low utilization, technology, etc.). This may lead to hospital closures that impact not just the locals with medical debt but entire towns [CITATION The21 \l 1033]. Then, some hospitals use deceptive tactics to track down people who have outstanding bills. Most hospitals do not collect the majority of their debt, even in spite of the very aggressive actions of a few institutions. The majority of medical debt is just not collected. Affordable, high-quality medical care is a right, not a privilege yet with medical debts hospitals cannot sustain [CITATION Thi23 \l 1033].

Resources to cover Medical Bad Debt

Hospitals may minimize bad debt in a number of ways, including by identifying patients who pose a financial risk prior to surgery and setting up a payment schedule to prevent bad debt. The patient also benefits from having more financial control over their medical care. Reducing needless Emergency Room (ER) visits is another way to cut down on bad debt. In order to reduce the number of resources needed for non-emergency situations, doctors are doing this through the usage of telehealth. Thus, the likelihood of receiving unpaid care is decreased since fewer patients seek costly care when it is not necessary [CITATION Def23 \l 1033]. However, if such approaches did not succeed and a bad medical debt was incurred, patients can turn to other forms of support such as government financial assistance program or non-profit organizations (humanitarian assistance).

Government Financial Assistance Programs

Financial assistance programs also referred to as medical bill forgiveness initiatives. Those who cannot pay hospital expenses might get them waived or significantly reduced (discounted) health care to those who require aid with their medical expenses. Patients with inadequate insurance coverage and those without insurance may benefit from these initiatives. Both governments and medical provider may offer such services, examples of some popular US based programs available to patients with specific eligibility requirements [CITATION CFP22 \l 1033].

1) ***Medicaid***: This program offers low-income people and families, especially those with significant medical debt, health coverage. States have different eligibility requirements, but in general, medical costs are reimbursed retrospectively for up to three months before application.

2) ***Medicare***: This program is mostly for the elderly and some disabled people, although it can also pay for some hospital stays, outpatient treatment, and other medical costs.

3) ***Charitable Care and Financial Assistance Programs***: A lot of hospitals and clinics offer financial assistance and charitable care to people who are struggling with medical debt. Depending on their income and financial situation, they

may grant debt forgiveness, provide sliding-scale payments, or provide discounts.

4) ***Assistance Programs Exclusive to a State***: Several states provide their own initiatives to help citizens pay for medical bills. These might include coverage for particular ailments, particular therapies, or help with prescription medication.

5) ***Programs for Debt Forgiveness or Reduction***: Periodically, initiatives or programs run by the government are introduced to forgive or decrease medical debt for those who meet the requirements.

6) ***Health care provided by Veterans Affairs (VA):*** This is available to eligible veterans and covers a variety of medical services, including diseases and injuries sustained during military duty.

7) ***Supplemental Security Income (SSI) and Social Security Disability Insurance (SSDI):*** These government programs, which offer financial support to individuals with disabilities, may help indirectly with medical expenditures even if they do not explicitly address medical debt reduction.

Non-profit Organizations (Humanitarian Assistance)

Furthermore, patients could also be able to get assistance from advocacy groups or non-profit organizations (humanitarian entities) that provide financial assistance for medical bills as they are main groups that help those impacted by emergencies such as medical bad debt elimination assistance [CITATION Mak23 \l 1033]. As an example of such non-profit humanitarian organization is RIP Medical Debt USA, which They employ data analytics to identify the debt of the most vulnerable households: those with debts equal to or greater than 5% of yearly income, or those making less than four times the federal poverty limit (which varies by state and family size). Millions of dollars at a time, RIP purchases medical debt in bulk at a significant discount from its initial cost. Accordingly, a contribution reduces medical debt by approximately 100 times its worth. Patients all throughout the United States get letters stating that their medical debt has been cleared as a result of their combined efforts. There are no penalties or tax repercussions for them to think about. They are now debt-free for medical expenses [CITATION RIP23 \l 1033].

Standard Humanitarian Aid Matching Process

Matching between philanthropists and patients with medical debt can vary depending on the organization or program facilitating the assistance. However, literature revealed that there are common steps and criteria involved in the standard matching process summarized in this section as follows [CITATION Smi95 \l 1033], [CITATION Slo90 \l 1033].

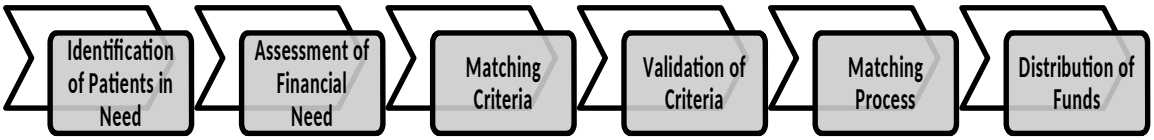

Figure 7: Standard Humanitarian Aid Matching Process Steps [CITATION Smi95 \l 1033], [CITATION Slo90 \l 1033]

Identification of Patients in Need: The first step is to identify patients who are struggling with medical debt and are in need

of financial assistance. This can be done through various channels, including hospitals, medical clinics, community organizations, and online platforms.

Assessment of Financial Need: Patients typically undergo an assessment of their financial situation to determine the extent of their medical debt and their ability to pay it off. This may involve providing documentation such as income statements, tax returns, and medical bills.

Matching Criteria: Matching criteria may vary depending on the specific program or organization providing assistance. Common criteria include:

- *Severity of medical debt*: Patients with higher levels of medical debt may receive priority.
- *Financial hardship*: Patients experiencing significant financial hardship, such as low income or lack of insurance coverage, may receive priority.
- *Medical condition*: Some programs may prioritize patients with certain medical conditions or those facing particularly challenging circumstances.
- *Geographic location*: Matching may take into account the location of the patient and the philanthropist to facilitate direct assistance or ensure that funds are distributed where they are needed most.

Validation of Criteria: To validate the matching criteria, organizations may require applicants to provide supporting documentation, such as medical bills, income statements, and proof of financial hardship. This information is typically reviewed by staff or volunteers to verify eligibility for assistance.

Matching Process: Once patients are identified and their eligibility is confirmed, they are matched with philanthropists or donors willing to provide financial assistance. This matching process may be facilitated by the organization overseeing the program, which connects patients with donors based on their preferences, criteria, and available resources.

Distribution of Funds: Once a match is made, funds are typically distributed directly to the medical provider or creditor to pay off the patient's debt. In some cases, funds may be provided directly to the patient to cover medical expenses.

Overall, the matching process between philanthropists and patients with medical debt involves identifying those in need, assessing their financial situation and eligibility, establishing matching criteria, validating eligibility, and facilitating the distribution of funds to alleviate the burden of medical debt.

Technological Innovations to support cover Bad Medical Debt

Technology in hospital medical billing has a bright and exciting future. Technology may save costs and mistakes while enhancing healthcare’s effectiveness, safety, and quality. Hospital billing and coding will be shaped in the future by these developments and trends such as the use of software robots to automate repetitive and rule-based processes is known as robotic process automation, or RPA. This technology will play a major role in hospital billing in the future. RPA has a high degree of accuracy and efficiency when handling jobs like data input, claims processing, and eligibility verification. Hospitals may enhance operational workflows, save costs, and free up staff time by automating these repetitive procedures. This will eventually improve billing results. To increase patient involvement and happiness, prevent redundancy, and improve coordination, technology allows safe data exchange between platforms and providers data sharing is used. Value-based payments technology assists in measuring patient outcomes, coordinating stakeholder incentives, and facilitating the shift to value-based payment models. Artificial intelligence (AI) and machine learning (ML) in predictive analytics may evaluate data to produce insights that boost performance, detect patterns and trends, improve decision-making and care

delivery, and customize treatment [CITATION Cor23 \l 1033]. The following sections highlight the technological innovations that are associated with bad medical debt; based on those identified, the majority are bound to support the reduction in bad debt creation or collection of bad medical debt yet not support patients in the elimination of such debt once it takes place. This can be deemed as the research gap.

dotData predictive analytics and machine learning

dotData was able to provide a useful method for data analysis. Correlations would be discovered by using machine learning and predictive analytics on a large, multifactorial data set. The number of data sources accessed and the total size of the client's data pool are both increased by dotDatas. Patient demographics, doctor details, insurance information, and medical specializations were among these new data sources. DotData considerably expanded the amount of data sources and individual data points, which were now in the millions, by include these more data points. The amount of data, however, was still manageable for dotData's AI algorithms. The goal was to extract meaningful signals from the data so that patient cohort-specific propensity-to-pay models could be generated and analyzed with accuracy. Previously, a strategy like this would have been unnecessarily complicated and slow, but dotData was sure that its techniques would offer the best chance to meet the client's (hospital operators') goal of a 25% decrease in past-due payments [CITATION dot22 \l 1033].

ConnectingCare Blockchain

By securely maintaining patient data and enabling communication between various healthcare providers, blockchain technology has been making significant progress toward changing the healthcare industry. ConnectingCare, a startup, is making good use of blockchain technology to expedite patient data access, facilitate cost prediction, and provide easy ways for patients to pay for their medical bills [CITATION PYM18 \l 1033]. With patient privacy and data security protected, this integration may increase healthcare delivery's efficacy and efficiency. Hospitals, communities, home care agencies, and other providers use this easiest way to send secure messages and referrals across Australia [CITATION Con23 \l 1033].

ScruPay smartphone app

With the help of the mobile payment software ScruPay, consumers may use their cellphones to conduct cashless purchases. It is intended to make different financial tasks easier, such as sending and receiving money, paying bills, buying products and services, and occasionally even dividing bills among friends or family, as of my most recent update. More specifically, it is working to make the healthcare payments system better by giving people who are still paying their hospital and doctor bills more information, or reminders, if they prefer. For instance, according to a statement from the Atlanta-based firm, ScrubPay "provides SMS and email notifications when a patient’s next payment is due, taking the worry out of paying their medical bills on time and allowing them to better manage their healthcare expenses." Through the use of a smartphone app, patients may collaborate with physicians to create flexible payment plans thanks to the company's technology [CITATION PYM18 \l 1033].

Hackensack Meridian Health Revenue Cycle Nordis Technology

Hackensack Meridian Health is becoming a high-performing healthcare business with the use of revenue cycle technology, particularly in patient collections and financial experiences. For the majority of hospitals, however, utilizing technology to enhance the revenue cycle is still an ongoing process. Healthcare providers still collect patient financial obligations using manual and paper methods, which has made the process take longer and be less effective. Even in cases where patients had a great clinical contact, ineffective and complicated systems might nonetheless negatively affect the overall patient experience. Their main goal is to make sure that the bills their patients get from Hackensack Meridian Health are understandable to them and include explanations for the charges they are being requested to pay. The goal is for the statement to accurately reflect the fact that a patient is getting a bill if it is their obligation as specified by their insurance company whether that be their deductible, coinsurance, or copayment. It should also be included on the bill if Hackensack Meridian Health is sending one because the patient's insurance company has not paid for the care or because their benefits have run out. In order to provide a high-quality patient experience during the billing and patient collection process, Hackensack Meridian Health has partnered with Nordis Technologies to utilize their revenue cycle technology. In addition to outlining the patient's financial responsibilities and the rationale behind them, patient statements must to include payment instructions. TD Bank and Hackensack Meridian Health have teamed up to provide an online payment solution. Through Nordis and TD Bank, Hackensack Meridian Health offers what it calls a "fully integrated patient billing and payments solution" that includes simpler-to-understand information and quick payment options. The health system has used the technology to convert over hundreds of thousands of paper payments into electronic and self-service online payments, replacing manual payment methods. Furthermore, even with all of the technology being used, the process is more customized. In order to confirm patient insurance and benefits, providers such as Hackensack Meridian Health have also introduced automated procedures in financial clearance. This aids the healthcare system in providing patients with an estimated range of costs for elective procedures [CITATION Rev22 \l 1033].

Factors of the proposed SMART blockchain healthcare platform

According to [CITATION Cho20 \l 1033], in order to install SMART systems based on blockchain technology successfully, implementers need to take into account a number of variables. The first is the relative benefit, which explains why the blockchain intelligent platform is seen as novel and superior to previous operating systems; in other words, decision-makers would have to ascertain just how advantageous the platform is. The potential end users' adoption rate of the new platform would accelerate with increasing degree. Furthermore, the second element is compatibility, which means that the new blockchain SMART platform must be simple to connect with the current platform and any auxiliary ones; otherwise, the company would have to spend a lot of time and money breaking pre-existing platform norms. In addition, trialability the third aspect to be taken into account allows the platform to be put to the test directly by potential end users in order to gauge their approval and facilitate the acceptance of the change once it is implemented. The fourth component is observability, which emphasizes the significance of analyzing, conveying, and strategically showcasing the system's advantages to managers. Being able to see the system's deployment and witness the outcomes is a winning factor for adoption. The fifth aspect is the implemented platform's complexity, which should be minimized for ease of adoption and implementation. The implementation of blockchain technology-based platforms has been hindered by several causes, including technological, business environment, and governmental constraints. Elaborating on each will not be covered in this study, but it may serve as a basis for future scholarly investigations. Furthermore, [CITATION Dob18 \l 1033] went into additional depth about the advantages of using blockchain in the healthcare sector, as shown in Table 6.

Table 6: Factors of a SMART blockchain platform [CITATION Dob18 \l 1033]

Factor	Platform
Relative advantage	Ability to track the origins of products
	Decreases logistical transactional costs
	Permits open access to logistical activities
	Product information is available to customers prior to purchase decision-making
	Eliminating the need to depend on governmental entities for approvals
Compatibility	Decreases fraud risks
	Accessibility of product and good information to customers
	More lean operation (document-free and hashes dependent)
	IoT reliant communications by used vehicles to transport goods and products (V2V)
	Enhanced product lifecycle tracking and traceability
Trialability	Give testers the freedom to regulate how they participate and share information from their observations
	Participation should not be made mandatory
Observability	Performance history of vehicle fleet is effectively tracked
	Ability to operate over Wi-Fi and using the internet
	Transforms the payment system by making it more effective
	Simplifies the process of product exchanging
	Increases the number of active blockchain platforms
Complexity	Eases paperwork
	Offer a robust network that permits exchanging resources
	Enhance the use of technology such as RFID and QR codes
	Ensure loading board are more reliable
	Allow access to multiple platforms

Blockchain is used to validate any network by describing how nodes are connected to one another. Approved blockchains, such as Ripple and Hyperledger Fabric, are those in which the node participants are already acquainted with the network. Similar to Ethereum and Bitcoin, blockchains may be made public. Anyone may join and access the network even if they are not on the public blockchain. Blockchain enables data transit inside a peer-to-peer network as well as the creation and sharing of digital ledgers. An illustration of the blockchain architecture is shown in Figure 8. Transactions may be managed and verified by users. Here, a centralized authority is not necessary. Since centralized processes like arbitration, modification, system configuration, and maintenance are expensive, the decentralized method significantly lowers such

costs. It frequently has scaling issues in spite of its tremendous efficiency [CITATION Gho23 \l 1033].

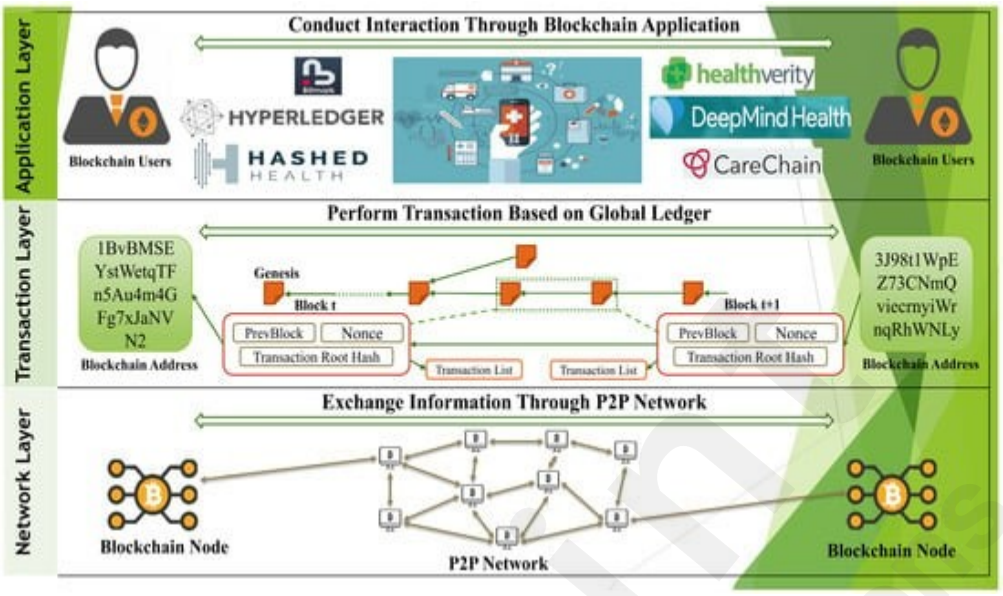

Figure 8: Healthcare Blockchain Architecture [CITATION Gho23 \l 1033]

There are three main types of blockchain; Table 7 provides a summary of their properties.

Table 7: Blockchain Types and Properties [CITATION Gho23 \l 1033]

Blockchain Type / Properties	Private Blockchain	Consortium Blockchain	Public Blockchain
Efficiency	High	High	Low
Determination of consensus	An organization	Chosen node set	All miners
Constancy	Could be tampered	Could be tampered	Almost impossible
Centralized	Yes	Partial	No
Reading authorization	Public or restricted	Public or restricted	Public
Process of Consensus	Approved	Approved	Permissionless

The primary distinction between blockchain applications in the broader healthcare space and those in the healthcare industry is that the latter employ blockchain primarily to establish safe and secure patient data management systems. A secure blockchain-based financial transaction service is also used by the healthcare industry. Ethereum blockchain-based cryptocurrencies is proposed to be used in this research solution (WELL-AI Platform) to tackle the financial transactions [CITATION Gho23 \l 1033].

Development of a "WELL-AI" SMART Blockchain Platform

There are several phases involved in developing an application product, ranging from ideation to implementation. A general rundown of the procedure starts with the ***creation of the idea***, by which a market requirement or issue is determined followed by listing all possible features and solutions [CITATION Bha94 \l 1033]. The second phase is ***market analysis*** in which the competition and intended audience is examined, the market desire for the solution is verified [CITATION Tat04 \l 1033]. The third phase is to ***specify goals and objectives*** of the solution by providing a clear explanation of the

application's goal and establish SMART goals that are specific, measurable, attainable, relevant, and time-bound [CITATION Mün20 \l 1033].

The fourth stage is ***organizing*** the development, by making a project plan that includes due dates and checkpoints. Moreover, describe the application's features, functionality, and extent. In addition, set aside funds and resources [CITATION Nih99 \l 1033]. The fifth stage is the ***creation*** phase, whereby the developer(s) will create the wireframes and mockups to visualize the user interface, design the user experience (UX) to provide a smooth communication. Moreover, design the user interface (UI) with both usefulness and beauty in mind [CITATION Jan96 \l 1033]. The sixth stage is the progress in which the developer(s) will select a stack of technologies that works well for the solution and write codes while adhering to coding standards and best practices. The agile development techniques will be used to implement the features [CITATION Ric10 \l 1033].

The seventh stage is ***testing or User Application Testing (UAT)***, the developed system or solution that is developed is tested and its integration. Any identified errors or snags are to be mitigated in this phase and lastly test the usability in order to make sure that the users have a good experience [CITATION Ota17 \l 1033]. The eighth stage is ***implementation***, after deciding on a hosting environment, the solution is launched and performance and error tracking monitoring tools are installed to ensure that the transition from development to productions is a smooth activity [CITATION Muf00 \l 1033]. The ninth stage is ***promotion and announcement*** through formulating a marketing plan to raise awareness and make use of several accessible platforms to advertise the solution [CITATION Sim01 \l 1033]. Once the solution is made available i.e. is open, the developer(s) will keep an eye on the customers reviews.

The next stage will be the ***reactions and rework*** stage, by which user reviews and comments are compiled, application use information is examined and the solution is refined in light of user input and industry development [CITATION Har14 \l 1033]. The eleventh stage is ***upkeeping and updating***, in this stage, developer(s) continue to offer assistance with bug fixes and problems, release upgrades that include enhancements and new features. Also, solution developers to continue to be receptive to customer demands and shifting market dynamics [CITATION Gou15 \l 1033]. The final stage is ***measurement***, during this phase, developers will plan for scalability as user numbers expand, besides, as needed, optimization of infrastructure and performance will take place. Furthermore, branching out into other markets or platforms [CITATION Nig95 \l 1033].

Effective teamwork, communication, and the ability to adjust to changes are essential to the application product's success during this phase. Additionally, you can make sure that your application stays competitive and current by keeping an eye on developing technology and market trends [CITATION Hol03 \l 1033].

Conclusion

Medical debt is a serious problem that affects a lot of nations worldwide and may be regarded as an international issue. Depending on variables including the healthcare system, insurance coverage, and general economic situations, medical debt varies in amount and kind between nations. Medical debt accumulation is more likely in nations where the healthcare system is mostly privatized and patients have personal responsibility for their medical costs, particularly for those without sufficient insurance coverage. While medical debt may be less common in nations with universal healthcare systems, problems like high taxes and lengthy wait periods for particular procedures can still be problems. Notwithstanding the

particular healthcare system in existence, people may experience debt, bankruptcy, or a delay in receiving medical care as a result of medical expenditures. The fact that this problem is worldwide emphasizes the necessity of accessible, all-inclusive healthcare systems that can lessen the financial strain on individuals and families. Reforms to healthcare policies, enhanced insurance coverage, and more assistance for those experiencing financial difficulties as a result of medical costs are frequently used in the fight against medical debt. Furthermore, there is a need for an innovative solution and platform that enables those in need to connect with humanitarian agencies for funds that cover such debts. The proposed solution 'WELL-AI' would assist. The examination of existing literature indicates a lack of a universally acknowledged platform or website exclusively aimed at bridging the humanitarian and health sectors to facilitate connections between patients burdened with medical debt and philanthropic individuals or organizations. While various organizations and platforms address issues concerning healthcare access, alleviating medical debt, and fostering philanthropy, their focus may not be specifically oriented toward linking patients grappling with medical debt to potential philanthropists. Such entities comprise non-profit organizations, crowdfunding platforms, and healthcare advocacy groups. This validates the necessity of suggesting a solution platform backed by both blockchain technology and artificial intelligence functionalities.

Future Areas of Research

Potential research areas encompass investigating ways to enhance the interoperability of various healthcare systems and platforms for humanitarian aid by utilizing blockchain technology as a unified framework. Another avenue of interest involves exploring the capability of a blockchain platform to empower patients with increased authority over their health data, facilitating secure sharing with healthcare providers and humanitarian organizations to streamline medical expense settlements. Furthermore, there is a need within humanitarian organizations to explore tactics for ensuring operational efficiency, including fund and resource allocation, and monitoring the outcomes of aid provided to patients burdened with medical debts, from a technical perspective. Additionally, research could delve into comparing user engagement with the blockchain platform across different stakeholders such as healthcare professionals, patients, and humanitarian workers. Moreover, an area ripe for investigation is how advancements in technology, data management, and ethical considerations can be propelled within these critical sectors through the deployment of a SMART blockchain healthcare platform connecting humanitarian relief efforts with healthcare systems. Furthermore, one could explore models of microfinance and community support, examining the potential of community-based networks and microfinance strategies to raise funds for debt relief and unforeseen medical expenses, possibly requiring partnerships with financial institutions and non-profit organizations. Another area of interest is researching public-private collaborations to promote cooperation between public and private entities like insurance companies, healthcare providers, and humanitarian relief groups, aiming to pool resources and devise sustainable approaches to address medical debt.

Limitation

According to [CITATION DTh19 \l 1033], limitation of studies is potential out of control weaknesses closely linked with the constraints of research design, statistical model, funding and other factors. The main limitations in the research are the 1) lack of previous research empirical studies on this particular topic whether within the healthcare or humanitarian industries 2) potential bias resulted from tools used for the data collection 3) potential lack of collaboration from professionals in the field due to concerns of any form of repercussions from openly expressing their professional opinion.

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