Reducing the burden of diabetes: digital health opportunities and challenges in Indonesia

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Abstract

The Indonesian health system is suffering from high economic and societal cost from noncommunicable diseases, such as diabetes. The increasing healthcare expenditure enforce the health system to adopt innovative solutions to deliver high quality of care with wide accessibility. Previous studies have suggested the implementation of digital health could enhance the value delivered within healthcare. However, no prior study has elaborated on what the factors driving and impeding digital health interventions from the users' perspective.

This research aims to investigate challenges and opportunities of digital health interventions within diabetes care in Indonesian healthcare from physicians' perspectives in order to enhance the value delivered to patients.

This is a cross-sectional, qualitative interview study. Purposive homogenous and snow-ball sampling methods were applied to recruit eleven medical doctors, including general physicians, internists, and endocrinologists. The obtained data were analyzed with a thematic approach.

The lack of policy and regulations within digital health as well as limitated coverage of the reimbursement system was indicated to hamper digital health interventions. In addition, this study also found potential barriers from the users; physicians and patients may have resistance to change and learn new ways of working. By contrast, there are clear needs within the diabetes cycle of care and perceived advantages of digital health which motivate physicians to adopt digital health. Technology enthusiasm was also argued to be factors driving digital health adoptions. Furthermore, this study suggested change management and multidisciplinary collaboration as implementation approaches to digital health interventions.

This study has described and explained the challenges and opportunities of digital health interventions within diabetes care in Indonesia. Additionally, this study also provides additional knowledge of digital health's potential to improve the outcome and societal cost of diabetes in the Indonesian health care system.

Keywords
mHealth, remote consultations, health information technology, diabetes, Indonesia

Popular Science Summary

Would you trust your doctors if they say:
"You have diabetes. I am going to prescribe you a mobile health application."

The healthcare industry is known to be late adopters or even laggards on adopting information technology to their services. The complexities of medical conditions encourage doctors to be conservative than agile. However, what would be the trade-offs if the innovation could significantly improve patient outcomes and reduce healthcare expenditure? This study bridges the existing gaps of physicians' perspectives, value-based healthcare, and digital health interventions in Indonesia; a middle-income country with more than 250 million population. Specifically, within diabetes care, which contributed a significant burden to the economic and societal cost to the health system.

This study aims to investigate medical doctors' perspectives on factors driving and impeding digital health interventions within diabetes care. To do so, eleven in-depth interviews were conducted with Indonesian doctors involved in diabetes care; general physicians, internists, and endocrinologists. The interview contents were further analyzed to understand what the current situations are and why.

After all, doctors are human, not superheroes.
There are gaps in diabetes care that doctors cannot cover. For instance, there are only around 120 endocrinologists in Indonesia to take care of more than 16 million diabetes patients. Clearly, they can use some help from information technologies to do so. Unfortunately, the path is not that simple; unclear regulations and reimbursement limitations was indicated to hamper digital health implementations. However, the rapid economic growth and the massive number of internet users (more than 100 million!) show that there are opportunities for digital health interventions to enhance the value delivered in healthcare.

There is no 'one that fits all' innovation, especially in healthcare; therefore, you need to adapt and lead the change!

List of Abbreviations

AI	Artificial Intelligence
BPJS *Kesehatan*	*Badan Pengelola Jaminan Sosial Kesehatan* (National health insurance implementing agency)
Covid-19	Corona virus disease 2019
DHIs	Digital Health Interventions
DRG	Disease-Related Group
eHealth	Electronic Health
EMR	Electronic Medical Record
FDA	Food and Drugs Administration
GDP	Gross Domestic Product
HCPs	Healthcare professionals
ICER	Incremental Cost-Effectiveness Ratio
ICT	Information and communications technology
IDF	International Diabetes Federation
INA-CBGs	Indonesia Case-Based Groups
JKN	*Jaminan Kesehatan Nasional* (National health insurance system)
mHealth	Mobile Health
MoH	Ministry of Health
NCD	Non-communicable disease
PBI	*Penerima Bantuan Iuran* (Contribution beneficiaries)
PERKENI	*Perkumpulan Endokrinologi Indonesia* (Indonesian Endocrinologist Association)
PHC	Primary healthcare
Puskesmas	*Pusat kesehatan masyarakat* (Community health center)
Riskesdas	*Riset kesehatan dasar* (Basic health research)
SaMD	Software as a Medical Device
UHC	Universal Health Coverage
US	United States
VBHC	Value-based healthcare
WHO	World Health Organization

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1. Introduction

The Indonesian health system is facing disparities in access to healthcare provision, human resources distribution, and access to medicine (1). Furthermore, the high prevalence of non-communicable diseases (NCDs), such as diabetes, also contribute to the healthcare burden, such as diabetes. Reports indicated that Indonesia's diabetes prevalence is over 16.5 million people (2) and costing healthcare expenditure of 3.9 billion USD (3). Consequently, there is a massive need in the health system to improve the populations' health and well-being.

Value-based healthcare (VBHC) framework was proposed to address the challenges within the healthcare system of Indonesia. VBHC framework was introduced by Porter, suggesting the delivery of high-quality healthcare with wide accessibility at a low cost (4). Prior studies argue that information and communication technology to be a fundamental lever to achieve the intended aim of VBHC (5). Hence, the implementation of digital health interventions (DHIs) would potentially enable the actualization of VBHC. Nonetheless, there is no prior study on the implementation of DHIs to actualize VBHC in Indonesia.

Healthcare professionals (HCPs) hold a crucial role as both users and prescribers of DHIs. Previous studies have shown HCPs' resistance as one of the significant barriers to DHIs implementation (6). Therefore, investigating HCPs' perception of DHIs is an important step to map out barriers and drivers of the adoptions. This study was designed to fill existing gaps between VBHC, DHIs, and HCPs perception, investigating the factors driving and impeding DHIs adoption within the diabetes care of Indonesia to enhance the value delivery for patients.

2. Literature review

The literature review section below describes the overview of the Indonesian health system profile, reimbursement structure, resources, and trends. Furthermore, the value-based healthcare model is proposed to alleviate the current burden of the health system, continued by the implementation of digital health interventions. Finally, the case of diabetes is explained as the main focus area of this study.

2.1. Country profile

Indonesia is the 4th most populous country worldwide, with 267.6 million people (7) and classified as a lower-middle-income country with a 5.37% annual gross domestic product (GDP) growth rate in the past decade (8). The GDP growth was ranked to be the second-fastest in Asia after China (9). Indonesia is the largest archipelago in the world, with 17,508 islands (10). Its unique geography contributes to the massive diversity of ethnic, cultural, and linguistic groups with 724 different languages and dialects (11). Consequently, the geographical characteristics and social diversity pitched in challenges to the Indonesian healthcare systems.

2.1.1. Healthcare structure

The health system of Indonesia consists of public and private providers financing (11). The term primary healthcare (PHC) in this research includes both public and private primary care. The public-primary healthcare is called community health center or *puskesmas* (*Pusat Kesehatan Masyarakat*). *Puskesmas* is responsible for both public health and personal health provision, while private primary care only covers the latter. Furthermore, the private providers encompass networks of non-profit and for-profit healthcare, as well as private practices of individual doctors and midwives (11). Figure 1 depicts the hierarchy of central, provincial, and district/municipality of the public authority.

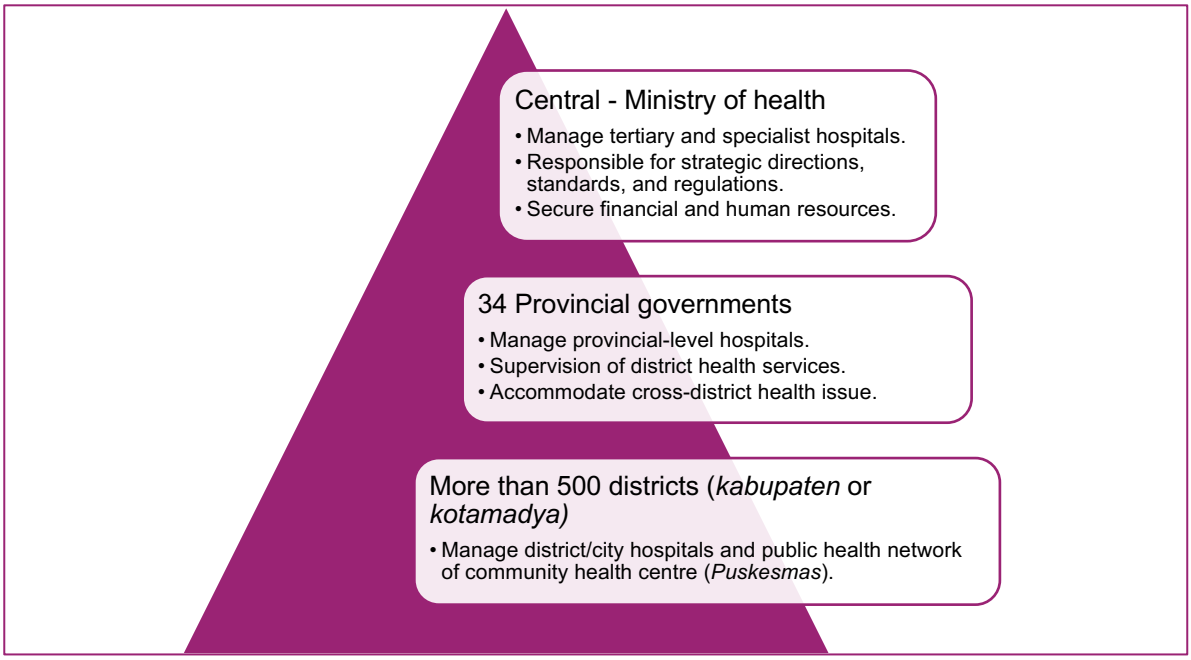

Figure 1. Hierarchy of the Indonesian health system, adapted from (11).

Indonesia has been progressing the health payment system toward universal health coverage (UHC) since 2014. Before the implementation of UHC, reports estimated that 47% of the population to have no access to adequate healthcare (9). Consequently, a single-payer UHC scheme was launched, designed to address access to effective and affordable healthcare (9). As the program reached 222 million members in 2019, the Indonesian national health insurance system or JKN (*Jaminan Kesehatan Nasional*) became the largest single-payer system (12).

JKN collects premiums from members, employers, and the government to a single health insurance implementing agency, namely BPJS *Kesehatan* (*Badan Pengelola Jaminan Sosial Kesehatan*) (11). Informal workers and their families without fixed salary contribute a monthly premium fee to BPJS *Kesehatan*, while employers pay a few percentages of the employee's salary to BPJS *Kesehatan* that also covers the employee's family members. The government waived the premiums of poor people, known as the contribution beneficiaries group or PBI (*Penerima Bantuan Iuran*).

2.1.2. Physical and human resources

The public system in Indonesia is evolving a transition from authoritarianism toward democracy and effective decentralization since 2001 (10, 11). Gunawan and Aungsuroch defined decentralization as "a process of delegating authority from central government and local government" (10, p.1572). However, since the decentralization was fairly recent, the health system is facing disparities between urban and rural areas. Some studies show the disparities of healthcare access between urban and rural populations. A study by Suryanto indicates that only the urban population has access to adequate emergency services (13). Another study by Assan et al. found that people living in small islands of *Bau bau* should travel by boats for 12 hours to reach the nearest hospital (14). Indonesia's large population, geographical area, and cultural diversity result in the burden of development and unequal provision to healthcare (10).

In 2017, the World Health Organization (WHO) reported that the number of hospital beds, PHC, and the physician to population ratios are among the lowest in Southeast Asia (11). The Indonesian Medical Council recorded the number of registered general and specialist physicians to be 186,148 (15), or 0.69 physicians per 1,000 residents. However, the ratio was still below the WHO recommendations of 1 physician per 1,000 residents (16). In addition to physicians' shortage, another study also indicates the disparity of physicians' distribution (10). The study shows that only 20% of total physicians work in rural and remote areas. However, according to WHO, Indonesia was expected to progress toward increased health infrastructure and increased HCPs to population ratio in the future (11).

2.1.3. Health economy

The payment model applied in the PHC is capitation, while the hospitals apply the Disease-Related Group (DRG). A study by Agustina et al. explains that *BPJS Kesehatan* reimburses payments to primary healthcare providers through capitations (9). BPJS Kesehatan pays the monthly capitation in advance, based on the number of registered members. However, Agustina argued that the amount is considered too low to cover the service standards and adequate competencies (9). On the other hand, reimbursements to hospital providers are done based on the DRG episodes, namely Indonesia case-based groups (INA-CBGs) set by the ministry of health (MoH) (11). *BPJS Kesehatan* suffered annual deficits and failed to pay its debt to hospitals since it was established. In 2018, MoH reported the annual deficits of *BPJS Kesehatan* reached 582.2 million USD (12). Delayed diagnosis of diseases and advanced complications was mentioned to contribute to the high cost of treatments that *BPJS Kesehatan* has to insure.

The rapid increase of access to healthcare provisions consequently increases the healthcare expenditure WHO reported that implementation of JKN enables more people to access healthcare without worrying about the cost (11). Nonetheless, MoH and *BPJS Kesehatan* are facing challenges of the increasing expenses on healthcare. Further evaluations should be done in order to define a way to optimize healthcare provision efficiently. The section below elaborates on a framework to improve the value delivery in healthcare at a reduced cost.

2.2. Value-based healthcare

Figure 2 summarizes the theoretical framework of this study; VBHC and its implementation in Indonesia, the use of information and communications technology (ICT) to enhance value, and digital health interventions.

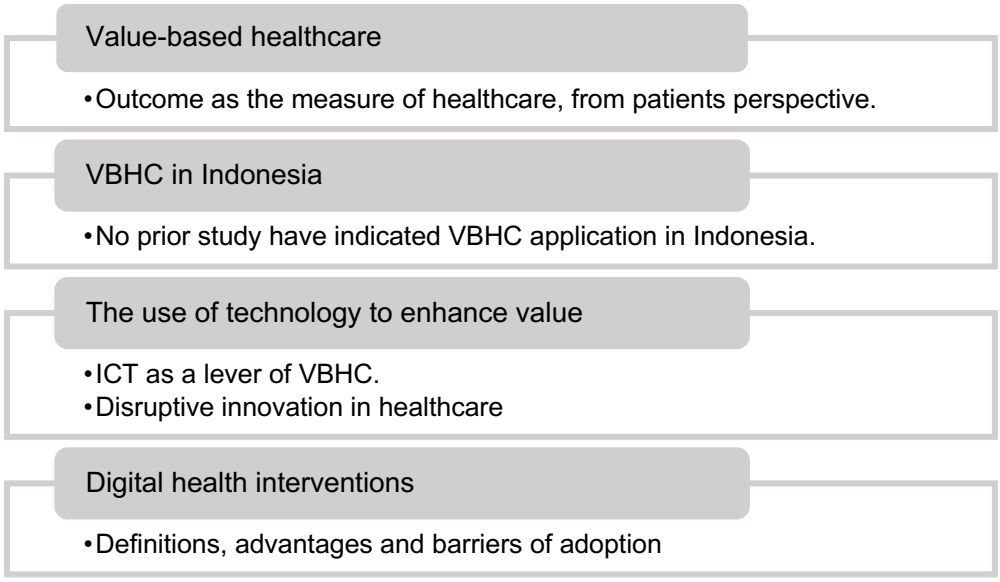

Figure 2. Theoritical framework of this study. Based on the author's analysis.

Due to the increasing cost of healthcare worldwide, Porter introduced a value-based healthcare model in 2006. Porter defines value in health care as 'the health outcome per dollar of cost expended' (17, p.4), as Traoré et al. elaborate the objective of VBHC in the formula below (5):

$$Objectives = low\ cost + high\ quality + wide\ accessibility$$

Porter argued that in VBHC, healthcare measures should be based on the health outcome instead of the service or performance (17). Thus, providers would focus on competing to deliver better health outcomes. According to Porter, the pay for service models encourages care providers to deliver more service, despite the treatment outcomes, thus increasing the healthcare cost. Moreover, Porter argued that performance-based reimbursement encourages HCPs to only adhere to treatment guidelines, despite the patient's variability.

The VBHC framework suggests the overall quality of care to be measured from the patients' perspective (4). The patient's health outcome is not merely the absence of disease but also taking into account their overall well-being. Hillary et al. illustrated the VBHC concept with a patient with a broken leg that was healed; however, there were pain and unrestored functions remained (18). Thus, according to Porter, healthcare value is created within the full cycle of care, taking into account the preventive, promotive, rehabilitative, and palliative efforts (19). A holistic perspective was argued to enable payers to determine cost-effective medical efforts that contribute the most value within the cycle of care.

Several studies have discussed the advantages of VBHC to improve the quality of healthcare at a reduced cost by looking beyond economic perspectives. Traoré suggested a multisectoral collaboration model between each level of healthcare level to form a simple medical workflow (5). The model provides a holistic simulation of the healthcare system by looking

at each stakeholders' perspective. Pitta and Laric illustrated the value exchange in healthcare in **Figure 3 (20)**. Pitta and Laric argued that stakeholders in healthcare are intercorrelated to each other, exchanging different values. For example, from the patients' perspective, the desired value might be health improved outcomes and well-being. However, from the payers' perspective, the desired value might be the reduced economic cost.

Another study by Arevalo in the United States (US) indicates that a reduced patient co-payment design of insurance resulted in increased medication adherence among diabetic patients, and consequently, improved blood glucose results (21). The study suggests a co-payment health premium based on patient medication adherence and treatment outcome. The co-payment design was argued to increase patients' motivation to adhere to treatment recommendations in exchange for fewer premiums. On the other hand, the insurers get the benefit of the reduced cost of complications treatment from better medical prognosis. In conclusion, VBHC requires a comprehension of the incentive of each stakeholder.

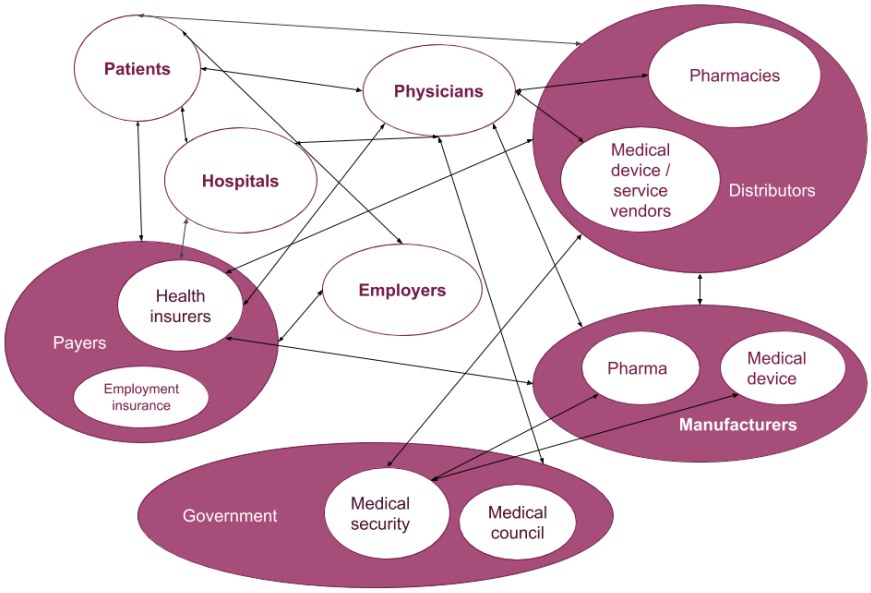

Figure 3. Stakeholders' relationships in the healthcare value chain. Adapted from (20).

Although Porter proposed VBHC as a strategic framework to reduce societal the cost of healthcare, nevertheless, there is a lack of empirical study that supports VBHC. Tsevat and Moriates argued in a study that VBHC is a theoretical aim of what healthcare should deliver; thus, it can be achieved with other frameworks of approach (22). Incremental Cost-Effectiveness Ratio (ICER) and bundled payment for an episode of care are examples of tools to achieve VBHC. However, a study by Ebbevi in Sweden found that the implementation of VBHC in chronic care did not address the 'patient perspective' in the case of rheumatoid arthritis (23). Ebbevi studied the implementation of Porter's suggestion three-tier model of outcome measures within rheumatoid arthritis care; nonetheless, the study found unimproved patient outcomes.

2.2.1. VBHC initiatives in Indonesia

No prior study has indicated the adoption of VBHC in Indonesia. On the other hand, a new policy by BPJS *Kesehatan* in 2019 indicated an initial shift toward performance instead of service. The policy regulates the monthly capitation of PHC to be paid based on the assessments of certain performance indicators (24). Among the indicators are the ratio of

chronic disease in well-controlled conditions, such as routine blood glucose or blood pressure level. Consequently, policy engages PHC to focus on the preventive and promotive that is less expensive than the curative (25). Although the performance-based payments did not adhere to VBHC as Porter proposed, the performance-based capitations resemble a closer move toward outcome-focused healthcare than the pay-for-service model. Should the indicators measure the health outcome instead, then the reimbursements would be more aligned with the VBHC.

2.2.2. The use of technology to enhance the value

Albeit the definite path to reach a high quality of care at a reduced cost is still unknown, previous studies have shown the utilization of ICT as a crucial step. According to Arevalo, defining the high-value healthcare services requires the implementation of ICT as a lever (21). Personalized treatment requires rigorous data on patient health; thus, comprehensive health tracking facilitated by information technology would enable patient management customizations. Similarly, Hillary et al. also argued that information technology is crucial to support healthcare transformation and help clinicians eliminate practices that contribute more cost without improving quality (18).

Furthermore, Christensen argued that the presence of information technology enables an organization with limited resources to challenge an established incumbent business, a process he defined as ‘disruption’ (26). In parallel with VBHC, disruption may enable healthcare to deliver solid value despite resource limitations. Previous studies have suggested the potentials of disruptive technology to improve healthcare in several ways. Yellowlees argued in a study that disruptive technologies ease the communication between patients and PHC providers, potentially shifting workloads of higher-cost providers (i.e., specialists care) to lower-cost providers (27). Moreover, disruptive innovation enables health startups to compete with established companies, thus improving the competition toward the value propositions. Similarly, Porter argued that the current competition in healthcare only shifts the cost from one to the other without adding value, defined as zero-sum competition (17).

Additionally, information technology enables multidisciplinary coordination of care to work accordingly. Fragmentation of care remained as one significant cause of healthcare inefficiency, according to Porter (4). The VBHC framework stresses out the difficulties of measuring value in medical conditions that involve interdisciplinary specialties. The difficulties cause healthcare providers to assess only particular interventions that were easy to be measured rather than the essential outcomes. Similarly, in disruptive innovation, Hwang and Christensen argued that health information technology has the role of bridging different care together to deliver patient-centered care (6). Hence, information technology allows a holistic understanding of the whole cycle of care, which is essential to determine value.

Finally, previous studies have explained the approach and challenge of adopting information technologies in healthcare. Hwang and Christensen presented a framework for utilizing disruptive technologies in healthcare's business model (6). The business model encompasses for main components; the defined value propositions, the profit formula between the costs and margin, the process of collaboration, and the alignment of resources. Hwang and Christensen suggested that the four components would enable innovators to deliver tremendous value. On the other hand, Chowdhury argued that healthcare is slow in implementing disruptive innovation due to the top-down approach, which did not accommodate the complexities of health provisions (28). The study prefers a bottom-up

approach in order to build realistic and intuitive digital health solutions for healthcare. Therefore, assessing HCPs' insights are necessary before the application of innovation. The subsection below explains the history of information technology applications within healthcare, including its known benefits and barriers.

2.2.3. Digital health interventions

The application of information technology in healthcare has evolved numerous innovations, aiming to improve health and well-being. WHO explained that the application started with the computerization of activities, defined as electronic health (eHealth) (29). An example of the early e-health activities was the change of paper-based medical records to electronic medical records (EMR). According to WHO, the presence of wireless technologies in the 2000s enables communication and remote access to health information, namely mobile-health (mHealth) (29). mHealth enables HCPs to access health data remotely, despite the geographical distance. Further on, WHO defined the term digital health as "a broad umbrella term encompassing eHealth (which includes mHealth), as well as emerging areas, such as the use of advanced computing sciences in 'big data,' genomics and artificial intelligence (AI)" (29, p.1).

Numerous studies have shown that the application of DHIs can increase healthcare access, improve efficiency, and contribute to better health outcomes. Weinstein et al. argued that DHIs facilitate great improvements in healthcare service coverage (30). The study explained that the use of teleradiology increased rapid access to radiology diagnostics in rural areas of the US. Furthermore, other studies also indicate that the implementation of eHealth improved physicians' satisfaction by facilitating well-elaborated patient data management, reduce the number of loss-to-follow-up cases, and improve treatment efficacy (31, 32). Miller et al. suggested that the accumulated data from EMR could help policymakers at the national and regional levels develop well-informed community health programs (33). Therefore, the study by Miller et al. shows the necessity to engage a greater number of HCPs as well as hospital managers to implement EMR in order to obtain the maximum benefit of digital health.

However, some barriers were named to impede the adoption of DHI, such as cost, HCPs acceptance, scientific evidence, as well as data and regulatory issues. Firstly, a study by Shah and Garg listed the cost of DHI and the requirements as the first impediments (34). Investing in digital health would require a large sum of funds for the procurement, training, and maintenance. Secondly, Mishra suggested that careful assessment should be done before extensive investment, especially from the HCPs aspect (35). Mishra’s study explains that HCPs experienced some fear that DHI can potentially replace their work in the future. Similarly, Miller also found that physicians' attitudes, high initial time investment, and lack of incentives as challenges to implementing DHI (33). Both Mishra and Miller's studies indicate that implementing DHI aside from the financial investment also requires non-financial levers to transform the existing attitude and behavior of HCPs. Finally, there is limited data concerning the safety, efficacy, and cost-effectiveness of DHI. The study by Mishra also stated that data protection and data security policies were still controversial regarding data ownership and the risk of a data breach (35). Therefore, there is a need for regulations to utilize DHIs in a reduced risk of harm.

2.3. The case of diabetes

Non-communicable diseases contribute to massive challenges in the Indonesian health system and causing 64% of death, even more than infectious diseases (13). Diabetes is one of the significant NCD which contribute to high mortality and morbidity. A study by Soewondo et al. claimed that diabetes was ranked as the third cause of mortality after stroke and hypertension (1). The subsections below explain the challenge of diabetes care in Indonesia as well as digital health opportunities to address the unmet needs.

2.3.1. Challenges of diabetes care in Indonesia

Not only contributing to the mortality, but challenges of diabetes care in Indonesia also result in a high economic burden in the Indonesian health system. According to a multi-centered study by Cholil et al. in primary, secondary, and tertiary healthcare across Indonesia, the health outcomes of diabetic patients remained unsatisfactory (36). Only 30.8% of subjects included in the study achieved the targeted glycemic level, and more than half of all subjects were reported to suffer from complications. Consequently, poor glycemic control leads to massive healthcare expenditure for the treatment of the complications, increasing the economic burden of the health system. International Diabetes Federation (IDF) reported that the Indonesian healthcare expenditure of diabetes reached 3.9 billion USD in 2019 and estimated an increase to 4.6 billion USD in 2030 (3).

Poor diabetes screening and limited access to medicines were claimed to cause high mortality and morbidity of diabetes. According to the basic health research or *Riskesdas* (*Riset Kesehatan Dasar*), 2% of the population aged ≥ 15 years old have been diagnosed with diabetes by doctors (2), or 3.9 million people. However, more than half of the diabetes population remains undiagnosed. *Riskesdas* also reported the actual prevalence of diabetes to be 8.5% (2), or 16.5 million people. Diabetes is often detected when complications have arisen, thus worsen the prognosis (1). Further on, research by Beran et al. indicates that the lack of insulin may contribute to poor patient outcomes (37). WHO reports that insulin treatments were not available in primary healthcare (38). *Riskesdas* in 2018 also reported that only 16% of all patients diagnosed with diabetes have access to insulin (2) or 622 thousand patients (36). Insulin replacement is the main therapy for type 1 diabetes and can provide better glycaemic control for many type 2 diabetes patients (39, 40). Figure 4 depicts the pyramid of the diabetes population in Indonesia.

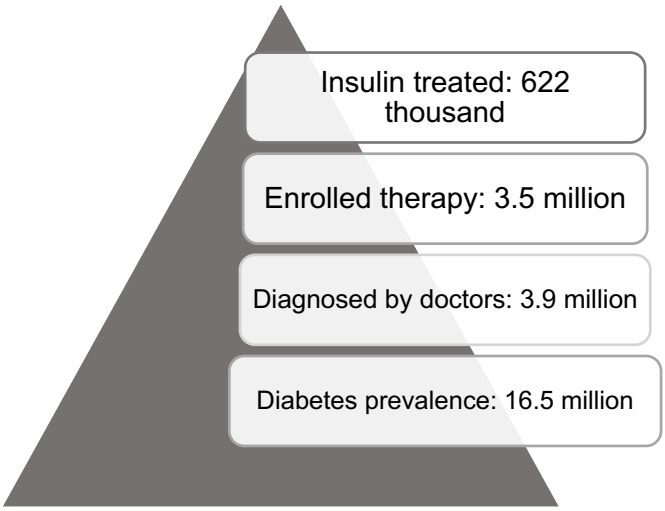

Figure 4. Pyramid of diabetes prevalence in Indonesia. Adapted from (2).

On the other hand, the burden of diabetes in Indonesia is predicted to worsen in the future due to the growing aging population and obesity prevalence, as argued by Lopez-Bastida et al(41). The World Bank reported the life expectancy at birth in Indonesia to progressively increase from 56.4 in 1977, to 64.9 in 1997, and finally 71.2 in 2017 (42). Similarly, *Riskesdas* reported that obesity prevalence among adults (>18 years) was increased from 15.4% in 2013 (43) to 21.8% in 2018 (2). Therefore, the Indonesian health system has to take intense action to address the rising problem of diabetes.

2.3.2. Opportunities for digital health interventions

Iyengar et al. argued that digital health could assist diabetes care in three ways (44). The first is through cloud-connected glucose monitoring systems. Frequent glucose monitoring is suggested to be a more precise indicator of glycemic control than the widely used standard, Hemoglobin A_{1c}, in previous studies (45). Therefore, cloud-connected glucose monitoring systems could potentially improve clinical outcomes. The second way Iyengar suggested is through telehealth service (44). Telehealth allows patients and HCPs to communicate remotely via video or voice calls as well as text messaging. Thus, telehealth can improve access to physicians and expanding the geographical area of coverage. The third way Iyengar mentioned was data management platforms such as mobile health applications (44). Physicians recommend patients to record their home blood glucose level, diet, and physical activity in a logbook (Personal communication, P Lestari, 2019 Oct 31). The logbook will help HCPs monitor patients' daily behavior in outpatient care. However, human errors in the recording were unavoidable. Numbers got forgotten or miswritten. Hence, mobile health applications can potentially ease both patients and HCPs from working on managing important health information.

2.4. Problem statement

The massive burden of diabetes challenges the Indonesian healthcare system to come up with an innovative solution. Moreover, future estimates have indicated that diabetes trends in Indonesia would increase further and, consequently, cost even more healthcare expenditures. The VBHC framework proposed a theory of reducing the societal cost and by shifting healthcare competition toward the outcome. Previous studies have claimed digital health to be a fundamental lever to achieve the objectives of VBHC. Access to comprehensive data would enable decision-makers to distinguish cost-efficient procedures and physicians to tailor personalized treatments. Further on, DHIs also have the potentials of increasing access to healthcare as well as reducing the work burden of both patients and physicians.

Aside from VBHC, DHIs can also contribute to addressing the existing hurdles of diabetes management. Comprehensive records of patient's glucose level and behavioral change are crucial in diabetes management; however, they remain as hurdles. Cloud-connected glucose monitoring, telehealth, and data management were named as three features of DHIs that can assist diabetes management. Rigorous data recorded by DHIs reflects the actual conditions of the patient’s behavior. Hence, this would be valuable information to help HCPs compose personalized patient education and encourage behavioral change. Previous studies have tested positive relation between DHI effects on patient education. However, more efforts shall be made to map out an effective implementation approach, specifically in Indonesia.

Based on the author's pre-investigation efforts, several DHIs have been implemented in Indonesia. There are several telehealth applications in the market, providing remote consultations with physicians and health articles. Another innovation in West Java involves community healthcare organizers to report activities using a mHealth application, iPosyandu, to *puskesmas* officials. However, the effectiveness of the DHIs as tools for achieving the objectives of VBHC remains unknown, especially in diabetes care. Moreover, there are limited studies on HCPs' perception of DHIs in Indonesia. HCPs hold a significant role as both users and prescribers of DHIs and physicians' resistance have been argued as strong barriers to DHIs. Therefore, there are gaps between the objectives of VBHC in diabetes care, how DHIs as levers can assist achievements of the intended objective, as well as potential resistance from HCPs. This study aims to fill the existing knowledge gaps by investigating the factors driving and impeding DHIs within diabetes care from physicians' perspectives to enhance the value delivered to patients.

3. Purpose of the study

3.1. Aim

This study aims to investigate the challenges and opportunities of digital health interventions within diabetes care in Indonesian healthcare from physicians' perspectives in order to enhance the value delivered to patients.

3.2. Research question(s)

1. What are the barriers impeding the adoption of digital health interventions within diabetes care in Indonesia?
2. What are the factors driving the adoption of digital health interventions within diabetes care in Indonesia?

3.3. Delimitations

There are three delimitations applied in this study. Firstly, this study would focus on the physicians' perspective, because in Indonesia, physicians are the central decision-makers of patient care. Nurse, pharmacists, and dietitians have a relatively minor role in the cycle of care since most check-ups are conducted by physicians every month. Furthermore, physicians have more influence within the healthcare management. Most healthcare institutions in Indonesia, such as PHC and hospitals, are led by a physician. Consequently, physicians are expected to have a global overview of healthcare, from a clinical and management perspective. Therefore, based on the author's judgments, physicians can answer the research questions of this study.

Secondly, the broad definition of digital health requires specific delimitations. DHIs of focus of this study would be remote patient monitoring in outpatient care, which includes the use of telehealth, mobile health applications, and integrated health records. Patient remote monitoring was considered to be the most relevant DHI addressing the main challenges of diabetes, namely blood glucose monitoring, patient education, and behavioral change.

Lastly, this study would focus on the urban area of Indonesia. Disparities between rural and urban areas were predicted to result in different problems in healthcare provisions. Existing DHIs are common in urban areas, despite the high need in rural areas as well. Due to time and resource limitations, this study would focus on physicians working in urban areas with more than 1 million.

4. Methods

4.1. Research design

The design of this research is a **qualitative study** with a **descripto-explanatory purpose** in a **cross-sectional** time frame. The **abduction theory development** is applied in this study.

A qualitative method is more suitable for exploring a new area (35). Since limited studies have been done on DHIs in diabetes care in Indonesia, the qualitative method is suitable for this study. Another option of the method was quantitative, which has the strength of explaining the numerical relationship between variables (46). Glaser suggested that the common utilization of a quantitative method is to verify a theory (47). On the other hand, the qualitative method provides a better description of the current situation and even mentioned as the best approach to generate theory on social systems and structure (47). In regards to this research's aim, a qualitative method was considered a better approach to investigate the challenges and opportunities of digital health implementations.

Previous studies have explored pre-defined expectations of the possible challenges and opportunities of digital health implementations. However, this study intended to elaborate on the situations further by describing the 'what' and 'why' through interviews. Thus, this study had a **descripto-explanatory purpose** aimed at *describ*ing the social situation and *explain*ing the potential causes (46). In this way, this study could further elaborate on the pre-defined expectations from the prior studies. Additionally, this purpose is also in line with the features of the qualitatives method in describing current situations and social systems.

A cross-sectional time frame is chosen due to several reasons. Firstly, it requires a short time that is suitable for the project time availability. Secondly, using other time frames, such as cohort or retrospective studies, would be difficult because the current knowledge of DHIs in diabetes care in Indonesia is not enough. Consequently, the status quo of digital health adoptions were not clear. An initial study to investigate a general description is needed in order to facilitate further research.

Finally, **abduction** theory development is applied in this study. Abduction theory development involves some iterations of theory building and deconstruction (21). This study began with the literature review, where the current knowledge of Indonesian healthcare was provided. VBHC framework and digital health were also introduced as a theory to address the existing challenges within the system. The theory was deconstructed into research questions and then derived into interview questions to investigate factors driving and impeding digital health adoptions. Further on, the obtained results were linked back to the research questions and the VBHC framework. From the process, conclusions were drawn to rebuild the proposed theory. As an outcome, implementation approaches of digital health utilization for achieving VBHC objectives are suggested based on the local context.

4.2. Data collection

The data of this study was collected through **interviews**. Interviews were considered most suitable with the aim and the design of the study. Another alternative to the data collection method considered was questionnaires. However, the weakness was that it does not allow the

researcher to ask interviewees follow-up questions (46). Follow-up questions are essential in order to fulfill the descripto-explanatory purpose of this study. Moreover, the practicality of verbal communication adds another reason to use interviews in this study. Verbal communication is arguably more efficient than written communication. Hence, participants would able to express more information verbally in a shorter time than writing. Based on considerations of suitability and participants' practicality, a verbal interview was chosen as the data collection method in this study.

Furthermore, to obtain deeper insight from subjects, semi-structured, or non-structured interviews were taken into consideration. Mishra preferred non-structured interviews in order to have an open question to find out significant impediments of diabetes care (35). However, an outline should be defined in this study to narrow down the scope and mentally prepare the interviewer. Non-structured interviews imposed the risk of the researcher having a less-focused conversation. Thus, **a semi-structured verbal interview is** considered a better approach due to its balance of focus and flexibility. Moreover, semi-structured interviews are more suitable for the descripto-explanatory purpose of this study, rather than non-structured interviews that are more suitable for exploratory study.

A possible bias in this study might be the interviewer bias. Since the researcher has a background as a physician, there might be different experiences from the participant's point of view, potentially affecting objectivity. In order to mitigate the bias, sufficient preparation should be done ahead of the interview. The preparations include creating an interview guide and interview questions, providing pre-interview information and consent forms, and setting the communication channels convenient for both parties (46). **Appendix 1** depicts the interview guide for this study. Further on, the information and consent form (**Appendix 2**) was written in the local language, Indonesian, to ease communication with participants. The communication channels offered for the interview was face to face, voice calls, or videoconferencing.
Finally, the interview was conducted in Indonesian. The language translation was conducted during data analysis when extracting the meaning units into condensed meaning, further explained in section *4.4. Method of analysis*.

4.3. Sampling

This study followed the four-steps approach to sampling in qualitative studies, according to Robinson (48). The steps include outlining a sample universe, determining sample size, selecting the sampling method, and recruiting participants.

Firstly, inclusion and exclusion criteria were defined to obtain relevant data for this study, as depicted in **Table 1**. A homogenous sample universe was drawn from the criteria, with the similarity of profession among participants as doctors. The rationale for maintaining sample homogeneity was to preserve the context in the defined manner (48). Therefore, the conclusion made is focused on a particular population. Characteristic differences might occur in the group, such as the physicians' specialization. However, the purpose of maintaining variety is to complement the findings to get the full overview of diabetes care. Since this study is not designed to compare differences and similarities between the roles, as the heterogeneous sampling purposes (48), homogeneity was applied.

Table 1. Inclusion and exclusion criteria of the subjects

Inclusion criteria	Exclusion criteria
Medical doctors: general physicians, internist, or endocrinologist.	Do not provide diabetes care in their practice.
Work in primary healthcare, clinics, or hospital in a city area.	Do not practice in Indonesia.
Agree to participate in the study.	Never hear or never use information technology within healthcare.

Secondly, according to Robinson, interview research for a specific subject area was recommended to limit the sample size between 3-16 (48). Due to the nature of this study as a postgraduate degree project, a minimum limit of 8 samples was set. However, the restraint of using a small sample size is the generalizability that only valid to the particular manners applied. The upper limit of the sample size was to reach theoretical saturation; a point of no new knowledge was found by conducting more interviews.

Thirdly, the sampling method used in this research is **non-probability sampling**, consisting of a combination of purposive homogenous and snow-ball sampling. A weakness of using this sampling method is the low likelihood of representation (46). This study includes views from both general and specialist physicians in different cities to avoid generalizations. Therefore, the sample would spread across a different network and represent better the general population.

Finally, given the combined sampling method, the recruitments of participants consisted of two parts. The first part was purposive sampling, where the researcher chose the first participant that fit the criteria (46). The second part was snow-balling, where the researcher asked for a recommendation(s) for another potential participant (s) at the end of the interview. Consequently, the researcher would able to reach a broader network of participants. If the referred participants were not able to participate in the study, the researcher selected another participant through the initial purposive sampling.

Eleven interviews were conducted with general physicians, internal medicine specialists, and subspecialists in endocrinology. The interview duration varied between 25 minutes to 70 minutes and was recorded with the interviewee's consent. Two interviews were conducted face-to-face, seven were conducted by phone, and two interviews over teleconference. The characteristics of interviewees are presented in **Table 2**.

Table 2. Interviewees' characteristics (n = 11).

Gender	Male: 8 (73%) Female: 3 (27%)
Specialty	General physicians: 5 (46%) Internists: 2 (18%) Endocrinologists: 4 (36%)
Type of practice	Private practice: 1 (9%) Primary healthcare: 3 (27%) Hospital: 7 (64%)
City	DKI Jakarta: 6 (56%) Bandung: 2 (18%) Bekasi: 1 (9%) Malang: 1 (9%) Tangerang: 1 (9%)

4.4. Method of analysis

The method of analysis followed the procedures of **thematic analysis,** according to Graneheim et al. (49). All the interviews were being transcribed and read thoroughly. Then, meaning units were highlighted, studied, and condensed. The meaning units were directly extracted from transcription; thus, they are still in Indonesian. The core meaning of transcription was extracted into condensed meanings and translated into English. According to Graneheim, condensing the text helped the author to simplify the text without removing the core (49). Consequently, condensation eased the codification process. Further on, themes were be assigned from the codes and linked one another based on the possible relationships. **Appendix 3**. illustrates a table used in the thematic analysis. In a similar study by Miller, the thematic method includes pattern matching and explanation building to describe the physicians' perspective of digital health (33). The themes would become the main topic of the findings, while the inter-correlated codes further explain the research questions. Consequently, the thematic analysis can accommodate the descripto-explanatory purpose of this study.

Furthermore, the result will be discussed and compared with previous studies, reports, as well as relevant regulations. Since the theory development applied in this study is abduction, therefore, there will be iterations of the theory building and incorporation. By this means, this study focuses on seeking relationships and possible explanations of each challenge and opportunity. Finally, based on the study findings, implementation approaches of DHIs to enhance the value delivery would be generated.

5. Ethical considerations

The ethical principles of autonomy, beneficence, and justice are applied in this study. According to Orb, the application of well-established ethical principles could mitigate inherent ethical issues in a qualitative study (50). Firstly, to honor the autonomy principle, the researcher asked for written or verbal consent from the participants for all the information obtained. A written information form was given to all participants and explained verbally before the interview. The form includes the aim, data processing, participants' right, contact information, and conflict of interest.

Secondly, the beneficence principle was applied by giving the participants the right to decline their participation in the study or withdraw their information afterward. The researcher respected their decision and would not insist. The researcher also offered the participants if they would like to be informed of the study's results. Hence, the participants can also earn benefits from their participation.

Thirdly, the researcher was aware of the sensitivity of data being contributed by the participants. Should the participants chose not to answer part of the interview questions, the researcher would not insist. All the data obtained was kept anonymous. There was no traceability between each answer to the participants' identity. A guiding document that contained their identity will be stored safely and could only be accessed by the researcher. Protecting the participants' privacy was one of the levers to implement the justice principle in this study.

Finally, the researcher has the full independence of choosing the study participants, even though this study was conducted in collaboration with a health technology company, Brighter AB. The participant was well-informed before the interview about the collaboration, knowing that the result of this study would be used for both academic purposes and input for DHI development at the company. **Appendix 4** depicts the ethical declaration form according to department of Learnings, Informatics, Management, and Ethics (LIME) of Karolinska Institutet. This study was also reviewed by the ethics committee, Faculty of Medicine, University of Indonesia in Jakarta. The ethical approval letter is attached in **Appendix 5**, number: KET 350 /UN2.F1/ETIK/PPM.00.02/20.

6. Result

Obtained information from the eleven interviewees was analyzed using the thematic approach by Graneheim (49). Three themes were defined from the analysis process, as depicted in **Figure 5**.

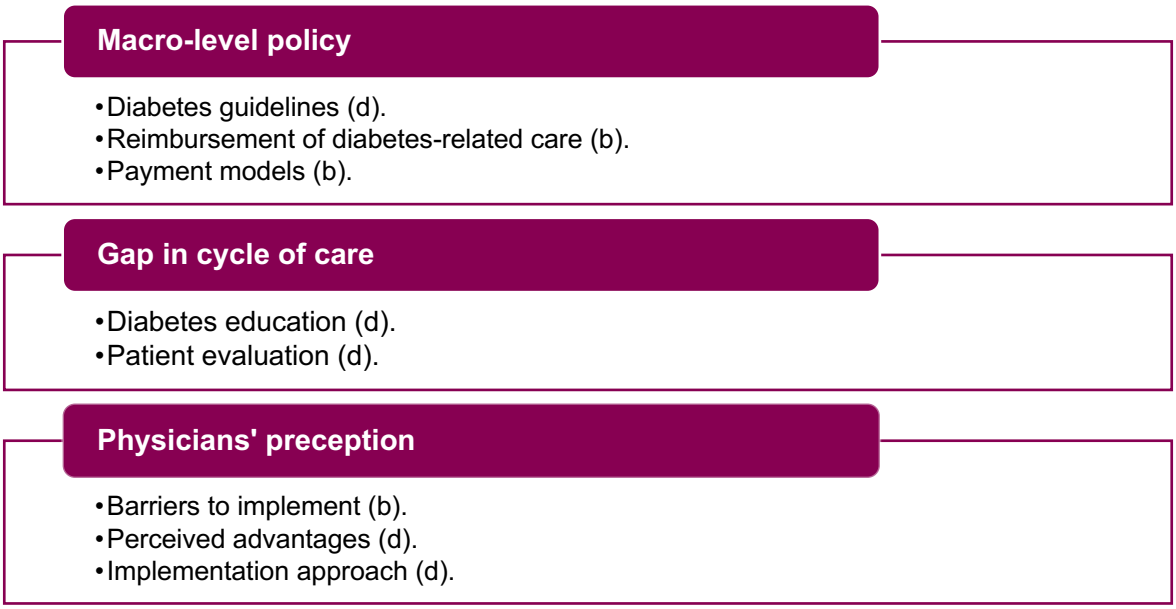

Figure 5. Main themes of the findings. (d) indicate factors driving digital health interventions, while (b) indicate barriers.

6.1. Macro-level policy

According to interviewees, the macro-level policy have significant influence to the implementation of DHIs. The absence of diabetes guidelines was argued to be a potential opportunity for digital health interventions. However, the rigid reimbursements coverage and payment models were perceived as barriers for digital health implementations.

6.1.1. Diabetes guidelines

Interviewees stated that there are no official guidelines on diabetes management from the MoH, especially regarding patient education and referral for complications screening. Treatment recommendations within diabetes are mainly from the Indonesian endocrinologists' association or PERKENI (*Perkumpulan Endokrinologi Indonesia*). However, since it is a recommendation; therefore, it did not have the same legitimacy as MoH's official guideline.

First of all, chronic disease such as diabetes requires the patient capability to self-managing their condition. Moreover, interviewees also added that social media's existence contributes to false information for patients in managing their diabetes and the massive exposure to information often misleads patients. Interviewees argued that MoH should set the standard of diabetes education given by HCPs to patients, similar to what the MoH did to other disease such as tuberculosis. Additionally, interviewees also argued that DHIs could be a tool for

standardizing diabetes educations, since internet-based materials are now preferred by patients.
"Nowadays people do not like flyers anymore. They prefer IT-based product, such as browsing, following information on social media or an application; it is now more suitable." – Participant 003.

Furthermore, interviewees were also concerned with the lack of standards regarding indications for referral to screen for complications at a different level of healthcare. The lack of referral standards led physicians to be hesitant to define when to refer patients to higher care. For example, an interviewee told the story of a patient who suffered from severe diabetic feet but was not referred to tertiary care. If the patient had been referred earlier, the patient could have had a better outcome. Furthermore, a few interviewees expressed their discontentment with the process of diabetes diagnosis, which is mostly conducted in the PHC. There is no adequate facility to screen the complications of diabetes in PHC, resulting in the delayed detection of complications. Several interviewees expressed their hope that information technology can aid the screening of diabetes complications. However, no interviewees state a clear example on what the help should be.

"So I believe government policy or official guideline from MoH needs to be released. Physicians should refer patients to higher care as per indications, for example, for the main diagnostic. Because ideally, eye examination has to be done (when diagnosing), as well as the screening of kidney function, electrocardiography, so it ***is*** *supposed to.. well treated or diagnosed, then (patients) have to get a proper diet. Even though in puskesmas, there are nutritionists, I feel it is not working yet. Moreover, in other primary clinics with no nutritionist. So it is absolutely required to have official guidelines from MoH to clarify comprehensive DM treatment in Indonesia."* – Interviewee 010

6.1.2. Reimbursements of diabetes-related care

Although the implementation of JKN has increased the access to healthcare, diabetes-related treatments being covered in the scheme is not adequate. Interviewees argued that limitations of the reimbursement system is a potential challenge of DHI implementations. Firstly, interviewees explained the self-monitoring blood glucose were not feasible to be conducted due to the exclusion of blood glucosemeter reimbursement. Interviewees mentioned medication adherence and behavioral change as the building blocks of diabetes treatment. Glucose monitoring is vital for evaluating whether the treatment was adequate. The glucose profile could also be HCP's reference for developing personalized diabetes education. Nonetheless, according to interviewees, neither the JKN nor privates insurances cover personal blood glucose meters and consumables in their scheme. The JKN scheme only covers monthly glucose checks at the primary clinic or hospitals, and none of the private insurance offer specific diabetes programs. Consequently, patients should provide the blood glucose meter themselves, out of pocket. Internists and endocrinologists were not happy with this situation because monitoring patients' blood glucose at least once a week is perceived to be crucial. Exclusion of self-testing blood glucose was seen as a significant obstacle to implement remote monitoring of diabetes care.

*"If we take examples of the procedure in daily practices, firstly blood, glucose (meter) is not included in BPJS (*Kesehatan*) coverage. So patients have to self-fund themselves, and the blood glucose (meter) is not cheap. Patients usually come to the doctor every month to check their blood glucose. So if… what does it call… the blood glucose measurements are included*

in BPJS (Kesehatan) coverage, it can be better. So they can self-test themselves." – Interviewee 007

Secondly, the range of diabetes-related treatment covered within the JKN scheme was argued to be minimal by the interviewees. The complexities of the disease required a wide variety of diabetes medications, from oral to injection. However, diabetes therapy delivered was rated insufficient due to the unavailability of some medicines. Interviewees mentioned only a few oral medications are available and reimbursed, especially in the PHC. Interviewees emphasized the need for facility improvements in the PHC in terms of medications and testing availability, to reduce the burden of later stage diabetes. Finally, the interviewees explained that patients' quality of life worsened when complications arose due to the limited coverage of the complications' treatment. For example, BPJS *Kesehatan* does not reimburse prosthetic limbs, and only covers dialysis twice a week.

6.1.3. Payment models

According to interviewees, neither BPJS nor MoH set any outcome indicators for diabetes care in hospitals; ergo the payment model was stated to be quantity-focused. Albeit PHCs apply performance-based capitation, the DRG models in hospitals still rely on patient diagnosis and care activity. Interviewees mentioned that hospitals only get paid by BPJS *Kesehatan* and private insurers if patients come for monthly consultation to the hospital. Hence, interviewees expressed their concerns that conducting diabetes care through digital health would not give financial incentives.

However, interviewees expected the coronavirus disease 19 (Covid-19) pandemic to shift the existing payment model. In order to reduce the risk of infection, physical consultation of diabetic patients at the hospital is conducted less frequent or remotely. Interviewees stated the Covid-19 pandemic contributed to the acceleration of DHI adoption in healthcare. BPJS *Kesehatan* now reimburses two months of diabetes medications for one time visit, e.g. allows patients to have consultation every two months instead of monthly. Interviewees argued that the Covid-19 pandemic would be the beginning of more acknowledgments regarding teleconsultations and remote monitoring from the government soon.

"With this Covid situation, we are scaling up the digitalization model in health care. (Consultation visits) That supposed to be monthly, now BPJS (Kesehatan)'s new policy allows doctors meeting (patient) every two months."- Interviewee 009

Interviewees agreed that the payment models and doctors' remunerations should be adjusted to accommodate DHIs. Without the universal standard of performance indicators, doctors remuneration still rely on the number of physical consultation in hospitals. Interviewees mentioned that certain hospitals do have internal KPI for physicians; however, the remuneration still focused on quantity. An example of remuneration preferred by one interviewee was fixed salary for physicians, in addition to some adjustment based on case complexities and performances. Therefore, the services delivered would focus more on quality, such as reducing complications and achieving better outcomes.

"Now it is a fee for services; if there is new consultation, every time patients come, we ***get*** *(paid). If we apply such systems using IT (digital health), perhaps, the payment should be like primary healthcare. For example, we take care of a certain number of patients, and then we got a certain amount. So if patients want to consult every day or once, the amount is flat. It is*

called capitation, the more we can educate better, they have less complain and less problem." – Interviewee 005

6.2. The gap in the cycle of care

Interviewees expressed their awareness and high expectations of information technology to fill the unmet needs within the diabetes care. Diabetes education and evaluation were argued to be the aspects of care where DHIs can contribute. However, patients' educational background may impede their adoptions.

6.2.1. Diabetes education

Interviewees expressed their expectations that digital tools could assist them addressing challenges in diabetes education. The short time for consultations between patients and physicians was mentioned as the main challenge of conducting adequate diabetes education. Furthermore, poor educational background of the patients becomes another barrier that hinders a successful diabetes education. In all, unsuccessful diabetes education contributes to a lack of treatment adherence among patients, resulting in complications and poor outcomes.

Further on, interviewees thought that DHIs have the potential to facilitate proper diabetes education. For example, social media enables frequent exposure of diabetes education materials. Interviewees perceived the use of social media to be more effective than distributing printed materials during consulation visits. Interviewees also explained that the duration of consultation between patients and physicians is very concise in both primary clinics and hospitals within the JKN scheme. On average, newly diagnosed patients have five to ten minutes of consultation, while repeating consultations are around three to five minutes. In contrast, hospitals within private insurance or out of pocket payments conducted a more extended consultation between ten to thirty minutes. Interviewees stressed the limited number of endocrinologists, contributed to this situation. The number of endocrinologists was presumed to be around 120 of all Indonesia, with 10 to 11 million estimated diabetes. Moreover, diabetes nurses or diabetes educators are stated as uncommon roles to be involved in patient care. Therefore, it is the physicians who has the role of communicating with patients. The short duration of consultations made it challenging to manage proper diabetes education, including medication compliance and lifestyle changes.

"If we take examples from my tertiary hospital (where I work) before BPJS Kesehatan existed, we have 120-140 patients per day. Now we have 50 patients per day, but in the secondary hospital where I practice after work, we have a surge of patients, even though we limit the number of patients (...). Let say I have 40 patients within 3 to 4 hours; that is not ideal for conducting proper education." – Interviewee 007

In addition to the short duration of consultation, several interviewees was concerned that patients' poor educational background could also impede digital health adoption. According to interviewees, illiteracy affects patients' understanding and self-awareness to manage their disease. Illiterate patients do not understand that the importance of diabetes management is for themselves to prevent complications. Interviewees have some concerns that patients' poor educational background would also hamper the implementation of DHIs within diabetes care a well. Interviewees illustrated that patients often apologize to physicians during consultation

visits when their test results were not well controlled. In other cases, patients did not return to the doctors because they felt they had recovered from the disease or followed other treatment recommendations, such as traditional medicine.

"On average, the middle class or low educated patients, when they get home, felt like they have recovered and do not return for control visits." – Interviewee 003

On the other hand, interviewees explained that Indonesians, in general, are heavy internet users, which was considered as potentials to implement DHIs. Especially the younger generations were perceived to be more enthusiastic with technology and more enthusiastic to have sn internet-based disease management. One interviewee mentioned the statistics that Indonesia has more than one hundred million internet users; which perceived to increase the likelihood of successful digital health adoption. The heavy use of the internet was seen as a driver of digital health implementation, in addition to the age of diabetes onset among Indonesian patients being early. Nevertheless, not all interviewees agreed that technology enthusiasm was parallel with the use of mobile health applications. One interviewee argued that based on his internal research, only one from 100 diabetes patients with smartphones has diabetes management application installed.

6.2.2. Patient evaluation

Interviewees mentioned challenges of evaluating diabetes patients as potentials factors in adopting DHIs. The main challenge of diabetes patients' evaluation is to keep track of patients' diet and physical activity. Interviewees explained that those factors are critical to analyzing patients' blood glucose variability. A thorough record is required to tailor the correct therapy for patients; however, HbA_{1c} does not specify the glucose variability over time. The existing approach taken to monitor blood glucose variability over time is to record in a dedicated journal along with the medications intake, diet, and physical exercise. Nevertheless, interviewees stated that patients often missed some recordings or lost the journal. Furthermore, physicians neither have enough time to explain the self-monitoring methods thoroughly nor analyze the patient records. Therefore, even though there are current applications that allow doctors monitoring their patients, the doctors only check patient conditions when contacted by their patients.

"So the (mean) glucose variability has been the trend for diabetes target control. It is now even argued that the mass recording or physical activity for medication intake timing should be written along with the glucose variability in order to capture the condition better." – Interviewee 010

Furthermore, interviewees expected DHIs to ease communication between multidisciplinary care, which encourage them to adopt DHIs. Multidisciplinary care in hospitals is often conducted when diabetes patients have comorbid conditions. Without the help of technology, interviewees stated that tracking parallel therapy was tricky. Moreover, interviewees argued that communications between PHC and hospitals are a challenge. Patients are referred to ~~as~~ internists when oral medications were not adequate. However, the PHC doctors usually lose track of the patients' record once referred, since the specialists would conduct the regular check-up. Eventually, the patient returns to the PHC to extend the referral or due to another health issue. As quoted from the interviewees, the PHC physicians could not track the ongoing medications. The situation became even more difficult when physicians have to

ensure drug interactions. Thus, DHIs were expected to assist physicians to solve the coordination of care.

"Usually, once the patient is referred to the internist, they never return to the clinic. They come every three months to extend the referral, but never to consult with the family doctor in the clinics. So we do not know how the patient's progress is." – Interviewee 002

According to interviewees, there are existing initiatives to conduct remote patient monitoring. One interviewee mentioned that PERKENI developed a two-way application where the doctor can see the patients' blood glucose levels remotely. Another conventional example from the interviewee was to use WhatsApp messenger to communicate with patients or caregivers to consult on the therapy and other recommendations from other doctors. Another interviewee formed a group community channel to share health promotion materials with patients and communicate with patients in between their consultation visits.

6.3 Physicians' perceptions to adopt DHIs

The lack of legality and resistance for change was considered as impediments by the physicians to adopt DHIs. On the other hand, interviewees explained time efficiency and data incentives are the perceived benefits that drive DHIs implementation. Further on, there were recommendations of the enactment of change management as well as Penta-helix collaboration to facilitate DHIs adoption in Indonesian healthcare.

6.3.1. Barriers to adopt

Interviewees argued that the absence of regulations regarding the legality of medical decisions taken remotely with telemedicine makes physicians unprotected if any potential adverse effect occurs in the future. Nonetheless, interviewees also stated that the situation did not stop the current digital health initiatives. Despite the presence of telemedicine and other digital health applications in the region, the government released no specific policy regarding the use of information technology in healthcare. Additionally, interviewees added that the unfinished discussion on the national bill for EMR also contributed HCPs' insecurities to perform a paperless procedure fully. Both HCPs and healthcare managers were concerned about adopting DHIs due to the risk of potential lawsuits.

"However, there are issues behind them (digital health interventions), whether the regulation or the medical decision that was guided by the internet has a power in law. Then, what if there are wrong decision and (unfavorable) effects from and to the patient." – Participant 008

Furthermore, interviewees also explained that inconsistencies in the role of authority in digital health add more skepticism to their intention to adopt. Firstly, the regional authority is still relying on the central government's role despite the decentralization. For example, the central government instructed all digital health innovators to establish one association that encompasses all existing solutions. Therefore, the regional authority could not regulate innovators at the local level. Secondly, the government also acted as a player in developing digital health solutions rather than policy-makers. Instead of controlling the current telemedicine applications, the government released another teleconsultation application,

Sehatpedia. These inconsistencies add more confusion for physicians and impede them from developing DHIs.

In addition, interviewees explained that there are resistance for change among healthcare managers and older doctors due to the difficulties in changing habits. The inconvenient process of learning new technologies was seen to hamper DHI adoptions even though it may contribute to the working efficiency. Private healthcare managers do not see whether the investment of new technologies could outweigh the benefits. Furthermore, the addition of new steps increased the resistance to adopting DHIs. The interface of remote monitoring applications shall be integrated with the existing system in hospitals and PHCs, thereupon not adding more steps in the work process. Therefore, interoperability is another critical consideration that increased the likelihood of adoptions.

6.3.2. Perceived benefits

All interviewees agreed that there are benefits of using DHIs in their practice. Firstly, DHIs could reduce the amount of work, thus saving more time. As mentioned above, time limitations are the main hurdles of physicians' work. Automatic reporting and access to big data are key features that could improve physicians' work efficiency. Interviewees argued having comprehensive data to be a huge advantage, particularly for physicians' academic work. DHIs enable physicians to gain easy access to big data that can be used for research.

"Actually, the data itself could be an incentive for physicians, especially for academia. Physicians can conduct studies for their Master, PhD, receive grants, without having to go to the field." – Interviewee 001

Secondly, interviewees argued that DHIs could mitigate the harm of diabetes in several ways. Firstly, DHIs can raise awareness among the high-risk population with diabetes and improve early diagnosis. Interviewees explained that since genetic factors influence diabetes, screening should be focused on the population with a family history of diabetes. Interviewees mentioned that using mHealth applications to calculate the risk of diabetes could be useful for this purpose. Secondly, diabetes can reduce the risk of hospital-acquired infection by enabling remote consultation. Interviewees explained that the Covid-19 pandemic restricted physical consultation between doctors and patients. Remote monitoring through telemedicine minimizes the risk of infection of the disease to diabetic patients. DHIs features to facilitate communications between HCPs and patients, regardless of the social distancing measures, were highly appreciated. Therefore, patients were able to get in contact with HCPs without increasing the risk of getting hospital infections.

6.3.3. Implementation approaches

Interviewees suggested the enaction of proper change management and Penta-helix collaboration to facilitate the adoption of DHI. Interviewees said change management helps mitigate the barriers of DHIs implementation both from an individual and organizational perspective. Interviewees determined change management strategy by firstly identifying at the internal drivers and barriers of adoption. Then, the action plan should be made based on the identified factors. According to the interviewee's experience, this approach was able to mitigate the physician's resistance to implement EMR.

Furthermore, interviewees also argued that Penta-helix collaborations between industry experts, academia, government administrators, payers, and society are necessary to scale up DHIs into a nation-wide program. The interviewee argued that approaches should be taken from the grassroots to bridge the gap between the community, government administration, and the ideal situations. For example, when empowering community health officers to conduct screening, the reporting tool should be tailored to meet the government's and academia's requirements to support research.

"So remember that to build a helicopter view, it begins from the bottom, not the top. (...) The creativity relies on the skill to build bridges that connect different needs, and then the connection adds collaboration with the government to solve issues in the country." – Interviewee 011

Physicians' perceptions, as expressed by the interviewees, reflect their considerations of adopting digital health as well as implementation approach suggestions based on their experience. Identifying internal barriers and drivers was argued to be a fundamental influence on the success of digital health implementation. Further on, in the next section, each of the factors driving and impeding digital health adoptions within diabetes care from all themes is discussed.

7. Discussion

This study aimed to investigate the challenge and opportunities of DHIs within diabetes care in Indonesian healthcare from the physicians' perspective in order to enhance the value delivered to patients. The result of this study described the potential drivers and barriers of DHI adoption within diabetes care in Indonesia, along with the possible explanations. **Table 3** summarizes the challenges and opportunities of digital health implementation within Indonesian diabetes care. Finally, this section presents the possible implementation approaches for DHIs.

Table 3. Drivers and barriers of digital health implementation

Barriers to implementing digital health	The lack of policy Reimbursement limitations Users' resistance
Drivers of digital health implementations	Unmet needs within diabetes care Perceived benefits of DHIs Technology enthusiasm

7.1. Challenges of digital health interventions

This study indicates that the challenges of DHIs in diabetes care in Indonesia: the lack of policy, reimbursement limitations, and the users' personal resistance. **Firstly**, the absence of policy and regulation affect HCPs' confidence to adopt DHIs, despite their awareness of its benefit. The existence of regulations facilitates safety assurance to HCPs as users as well as healthcare managers to adopt DHIs. As argued by Shuren et al., efficient regulations would tailor DHIs according to its potential risks and benefit, referring to the US Food and Drug Administration (FDA) regulations in regards to software as a medical device (SaMD) (51). Brall et al. also emphasized the necessity of ethical guidance in regards to digital health so that all stakeholders commit to their responsibilities, rights, and duties (52). Nevertheless, this study found that similar regulations for SaMD and ethical guidance in Indonesia have not been enacted. The absence of regulations raises concern among physicians regarding the safety of medical decisions influenced by DHIs and taken remotely. Although the absence of regulations did not stop the existing development of DHIs, however, this study indicates the need of clear regulations to support DHIs acceptance among physicians.

Inconsistent actions of the government were also found to add more concerns to the policy obscurities. The central government still holds a significant influence in decision making, despite decentralization. In accordance, a study by Maharani et al. explains the plausible cause of district hospitals achieving financial independency was the limited decision space of district managers (53). Maharani et al. also argued that to achieve decentralization, hospital and regional authority should be empowered to take control of their area. This study suggests that consistent decentralization can facilitate the implementation of DHIs. Due to the geographic and population size of Indonesia, it is critical to shift decision-making authority from central to regional government. Shortening the bureaucracy would improve the efficiency of administrative processes; thus, accelerating the utilizations of DHIs to increase access of healthcare in the regional level.

Secondly, no existing reimbursement scheme covers health services conducted through DHIs, neither from the public nor private insurance providers. The current reimbursement scheme does not facilitate remote monitoring of diabetes. Specifically, this study indicates that self-monitoring is not covered in the JKN scheme. Weinstein et al. also pointed the service reimbursement as a significant aspect of teleconsultations and mHealth applications in the US (30). Consequently, the limited coverage of third-party payers in telemedicine services would impede the implementation of digital health. Weinstein et al. also added the payment for costs of infrastructure and equipment upgrades as other barriers of long-term success in telemedicine, suggesting it is the government call to intervene with these barriers (30). On the contrary to Weinstein et al., this study indicates that multi-sectoral stakeholders could work together to achieve the intended benefits of DHIs through Penta-helix collaboration. The Penta-helix collaboration includes two additional stakeholders of payers and community from the previously known Triple-helix. This study indicates that in Indonesia, the payers could be a separate entity from the government or industry experts and the community may have significant influences to increase DHIs' likelihood of success.

Following the VBHC framework, this study found that the existing DRG payment model in the hospital causes diabetes management to focus on monthly consultation visits rather than patient outcomes. Porter argued that DRG models enable unnecessary and expensive services to be done without calculating its efficiency (17). Adjusting the payment models to be more outcome-focused will shift the competition in healthcare toward work efficiency. Hence, the payment models should be transformed to focus on outcomes and encourage healthcare managers to find more efficient ways of delivering a better quality of care, through the utilization of DHIs.

This study also showed discontentment of physicians regarding the exclusion of self-monitoring blood glucose and patient education program in hospitals from the JKN scheme. The exclusion was seen as a barrier to implement DHIs. Previous studies validate the discontentment and explain the effectiveness of self-testing blood glucose and patient education on reducing diabetes complications. Cameron et al. found the predicted self-monitoring model reduced the incidence of diabetes-related complications in the long term (54). Similarly, Brownson et al. also found diabetes self-management programs to be cost-effective due to its significant influence on reducing lifetime complications (55). Both studies provide strong arguments to the findings of this study that shifting diabetes management toward effective management and education. However, the JKN scheme does not include the reimbursement of blood glucosemeter and education programs in spite of the scientific evidences. In consequences, the reimbursement exclusions would hamper the implementation of DHIs within diabetes care; as well as the achievement of VBHC's objective to deliver high quality of care with wide accessibility at a reduced cost.

Thirdly, personal resistance of patients and HCPs as users also potentially hampers the adoption of DHIs. This study suggests that patients' socio-economic background affects DHIs adoption. Particularly, DHIs may only be suitable for well-literate, younger patients. Similarly, Sarkar et al. explained that the lack of internet access and training, inadequate social support, limited literacy, and e-health literacy are the possible mechanisms that influence the phenomenon (56). As found in this study, research by Miller also suggested the physicians' attitude, high initial time investment, and lack of incentives as challenges to implementing DHIs (33). To address users' resistance, Sarkar et al. suggested the need for internet and computer training to sustain DHIs (56). As no technologies could fit all social

context; therefore, innovations should be tailored in a precise manner to suit the local context and organizations.

7.2. Opportunities and recommendations

On the other hand, there are unmet needs within the diabetes cycle of care, its perceived benefits, and the demographic characteristics that potentially support the implementation of DHIs. **First of all**, this study found access to extensive data and time efficiency as two main perceived benefits and drivers of digital health adoption.

One, the accumulated data from DHIs can help both HCPs conduct research and policy-makers to develop rigorous health policy. Access to extensive data was stated to be a significant alleviation for HCPs who need academic research to continue their education or careers in academia. Similarly, previous studies have suggested that accumulated data from DHIs enable physicians to evaluate the most effective treatment among specific characteristics of the patient (31, 32). The input can potentially be a significant benefit in regards to Indonesia's diversity. AI-assisted analysis and treatment suggestions based on patient-recorded trends are crucial to delivering personalized care, thus fulfilling the fundamentals of diabetes management

Furthermore, at a macro-level, the accumulated data can provide recommendations for efficient diabetes treatment. This study also indicates the need for rigorous health policy and guidelines within diabetes care. The current reimbursement policy was mentioned not to cover the necessary aspect of patients' well-being. In parallel, a study by Turner also shows the value of evidence-based clinical guidelines for HCPs as the illustration of best practice and quality assurance (57). Previous studies have suggested the DHIs can contribute to the development of improved health policy and diabetes guidelines. Two studies by Hillary (18) and Miller et al. (18, 33) explain the advantages of the accumulated data to assist policy-makers in developing cost-efficient healthcare. In all, DHIs can help healthcare providers to measure the right aspect of care, which contributes the most to patients' well-being.

Two, time limitations repeatedly mentioned as the main challenges of health services by the interviewees. Possible explanations of the time limitations are the unintended consequences of DRG payment models and the shortage of physicians. This study indicates that DRG payment did not shift healthcare's aim to be outcome-focused, even though Tsevat argued that it is an example approach to achieve VBHC (22). Two studies by Shah (59) and Aulia (58, 59) respectively support the findings of this study, that the weakness of the bundled payments such as DRG is not outcome-focused. Furthermore, Aulia suggested that limiting the duration of service as a strategy taken by hospitals to reduce costs in DRG payment models (59). To achieve more reimbursements of patients, hospitals accommodate a large number of patients; thus, the duration of consultation became very short.

Second of all, there are gaps in the education and evaluation aspect of the diabetes cycle of care. This study indicates the gaps are potential opportunities where information technology can contribute through DHIs. In parallel, Weinstein et al. also argued for improved service coverage as the main benefit that increases the likelihood of telehealth, telemedicine, and mobile health applications to be successful (30). In conclusion, DHI can contribute to improving diabetes education by facilitating remote consultations with an interdisciplinary approach. For instance, consultation visits conducted every three months instead of monthly.

Hence, the duration of each visit can be longer due to the smaller amount of patients per day. In between the consultation visits, the patient can interact with physicians, nutritionists, or diabetes educators. This multidisciplinary approach would deliver effective diabetes education, thus, increasing the likelihood of successful behavioral change.

Furthermore, the findings of this study suggest that DHIs can facilitate early screenings of diabetes. The previous survey of Soewondo et al. argued the late diagnosis as one of the contributor of poor disease prognosis (1). Therefore, early screening may contribute to reducing the burden of the massive economic cost of diabetes-related complications. Similarly, Porter also suggested that diagnosis should be treated as a distinctive part of disease management because it can minimize costs later in the downstream (17). Nonetheless, this study found that the limited facility of the PHC hampered proper complications screening of diabetes. The risk calculation assistance from mobile health applications may help solve this problem by prioritizing high-risk patients to be screened, thus reducing diabetes-related complications.

Third of all, this study also indicates the socio-economy situation of Indonesia may have a positive impact to DHIs adoptions. Similar to a study by Suzuki et al., which elaborates on the relationship between the number of internet users and GDP growth in regards to telemedicine development and progressivity (60). GDP growth was suggested to influence infrastructure development and access to technology; therefore, increasing the likelihood of healthcare industry growth. Accordingly, with the estimated 141.3 million internet users by the end of 2022 (61) and the rapid increase of GCP (9), there is a high probability of telemedicine introduction in Indonesia.

In addition, the Covid-19 pandemic situation was found to promote the acceleration of DHIs. Following this finding, the Indonesian Medical Council recently released a regulation related to clinical authority and medical practice conducted through telemedicine during the Covid-19 pandemic (62). The regulation elaborates on the specific condition which allows remote medical decision; patients with serious condition should not be treated remotely and be referred to emergency care. Two studies by Bornstein (63) and Singh (63, 64) respectively confirm explanations of DHIs acceleration during the pandemic. As diabetes is one of the most significant comorbidities in Covid-19, prevention measures should be taken seriously. Both studies suggested telemedicine and remote monitoring in outpatient diabetes care to alleviate the risk of morbidity and mortality.

Finally, this study found **two main recommendations** that can potentially promote DHIs adoption. The first one is change management, which was mentioned as crucial for DHIs implementation at an organizational level. This study suggested investing substantial effort in developing an implementation strategy. Similarly, Martin and Voynov explained that digital health implementations require technological resources and social recourses (65). Martin and Voynov presented Kotter's eight phases approach for change:

1. Building senses of urgency,
2. Forming a guiding coalition,
3. Developing vision and strategy,
4. Giving voices to the vision and strategy,
5. Empowering broad-phased actions to encourage risk-taking,
6. Generating short term wins,
7. Consolidating more change, and
8. Anchoring the new approach to the organization's culture.

The second approach mentioned in this study, the Penta-helix collaboration, was stated as crucial to scale up innovation at the regional or national level. Academia and industry experts were considered to have the most knowledge on the latest technology and health sciences, while the government has the jurisdiction to reach a scalable population. Similarly, Murray argued that since DHIs itself are the intersection of medical, social, engineering, as well as computer science, thus a combination of these experts in addition to efficient management are fundamentals to develop the implementation method (66). Hence, the joint work between the multiple stakeholders can result in an effective implementation approach to scale up DHIs.

By contrast, previous literature also suggests that social change does not always come from multisectoral collaboration. Christensen introduced disruptive innovation, where a smaller organization with limited resources can challenge bigger, established organizations with the help of disruptive technologies (26). Furthermore, Hwang and Christensen's proposed business model indicates that a strong value proposition can be a significant strength of smaller organizations to sustain (6). However, the application of disruptive innovations does not only involve a positive impact. An example of disruptive innovation in Indonesia is the motorcycle ride-hailing application, Go-Jek. Suseno argued that despite its success, Go-Jek has also triggered negative disruption in socio-cultural, regulation, and competition (67). Similarly, this study also found that the lack of rules does not stop current telemedicine applications to evolve. In conclusion, external controversies and regulation barriers may exist in disruptive innovation. However, having a strong value proposition can help startups to pull through the barriers.

7.3. Strengths and limitations

The qualitative approach this study and the holistic perspective from the interviewees contribute to the main strength of this research. According to the researcher's knowledge, there is no prior study that studies physicians' perception of digital diabetes care in Indonesia. The balanced interviewees from generalists, specialists, and subspecialists in this study complement the qualitative approach. Therefore, this study provides a holistic perspective on diabetes care. In addition, interviewees have broad experiences in digital health, allowing the results to include existing initiatives and implementation approaches of DHIs. The experience enabled the interviewees to contribute a sound perspective from the regulations, health economy, clinical, social, and personal aspects of digital health implementation.

Furthermore, this study complies to the credibility and transferability criterion as defined by Saunders et al. (46). The credibility of this study was ensured by reflecting the information to a health economist in order to confirm the findings of this study. Moreover, this study described the research questions, delimitations, methods, findings, and interpretation thouroughly to comply with the transferability. The credibility and transferability techniques was applied in this study to provide both internal and external validity.

However, the majority of the insights are related to the JKN scheme and did not include private insurance and out-of-pocket payments. Interviewees did mention the private sector setting to some extent; however, the JKN scheme covered the majority of populations. The researcher considered the JKN scheme to be more relevant in this study since, based on the interviewees' insight, most patients preferred JKN scheme than private or out of pocket

payments. Furthermore, the interviewees' perspective remain to be confirmed to the other stakeholders' perspective, such as the authorities, payers, and patients. Efforts to mitigate the single-persepective of this study was to confirm the assumptions based on previous studies and experts. Therefore, studies regarding policy, reimbursements, and management are included in the discussion.

7.4. Connection to bioentrepreneurship

One definition of entrepreneurship is 'a process of sensing opportunities and creating innovation with determination to iterate' (68, p.1). The creation of innovation involves offering the right value; therefore, the agility of sensing the current need as an opportunity is required along the process. Eric Ries related entrepreneurship with the work in startups, which he defined as 'a human institution designed to create new product or service under extreme uncertainty' (69, p.8). Ries argued that the goal of a startup is to be quick on making iterations and customer insight. Therefore, exploring the user perspective is a fundamental aspect of entrepreneurship.

Furthermore, the term bioentrepreneurship involve the combination of entrepreneurship within the life sciences industry, including healthcare. Shiferaw argued that there is no 'one fits all' innovation; thus, adaptations of new health technology into local context are needed to increase the likelihood of success (70). Additionally, as Hwang and Christensen argued in a study, disruptive innovation within healthcare is facing barriers from HCPs due to their nature to sustaining innovation (6). In summary, the complexities of HCPs' work result in stronger resistance when introduced to innovations. Since the HCPs would be the main users of innovation in healthcare, as a consequence, the iteration process of healthcare startup seems to be a longer journey than other industries. The process of bioentrepreneurship requires in-depth assessment of users' insight in order to catalyze the iterations of innovation in healthcare. However, there was a knowledge gap between the physicians' perception and the value propositions of DHIs as facilitators of VBHC's objective, especially within diabetes care in Indonesia. Hence, this study investigated physicians' perspective as the users of DHIs to accelerate the iterations of healthcare innovation.

To bring the objectives into practice, this study contributes at least three additional knowledge to the concept of bioentrepreneurships. Firstly, this study has identified a clear need to improve work efficiency within healthcare and reduce economic cost in the context of diabetes care in Indonesia. Porter argued the necessity to see the whole care process and determine value exchange between stakeholders (17). Consequently, this study indicates that payers may see health expenditure as a critical value, while health outcomes and well-being are fundamental to patients. Secondly, this study also found that time limitations faced by HCPs could be both perceived as a value and a potential barrier for introducing innovations within healthcare. Therefore, this study suggested time efficiency as an aspect of considerations in developing innovations. Finally, possible implementation approaches for leading transformation in a healthcare organization was suggested. In all, this study shed another light to bioentrepreneurs who are considering to create innovations amidst the uncertainty of the healthcare industry.

7.5. Future research

Since this is a qualitative study to describe the existing social systems, thus, further confirmatory study is needed to evaluate the presumed facts found in this study. For example, A quantitative study focusing on the utilization of DHIs would verify its presumed correlation with the number of internet users in the population. Additionally, a study measuring behavioral and clinical outcome from DHIs may complement the hands-on knowledge and investigate further actual challenges and opportunities of digital health within diabetes care. Further on, perspective from other stakeholders' mentioned in this study, such as medical authorities, payers, and patients, are also left to be explored in order to confirm the holistic understanding of health system.

8. Conclusion

This study sought physicians' insight on the barriers and factors driving digital health implementations within diabetes care in Indonesia. The barriers include the lack of policy, limitations of reimbursement schemes, and personal resistance from the users. The existing health policy and reimbursements in Indonesia should be shifted toward the patient outcome in order to facilitate DHIs and to align with the VBHC framework. On the other hand, the factors driving digital health implementations are the unmet needs within diabetes care, the perceived benefits, and technology enthusiasm. Even though the overall aim of healthcare was suggested to deliver excellent health outcomes at a reduced cost, different stakeholders may perceived value differently. Consequently, defining the values for each stakeholder was suggested to be a fundamental step of transformation. This study indicates that time efficiency and big data are the main incentives for physicians when adopting DHIs in the context of diabetes care in Indonesia's urban areas.

This study also emphasizes the need of comprehensive implementation strategy for DHIs. Firstly, rigorous change management is fundamental to mitigate internal barriers, starting with creating the sense of urgency and trainings. There are no universal innovation that instantly fits to every local contexts, therefore, some adaptations need to be made to promote DHIs adoption. Secondly, digital health is a multidisciplinary itself between biomedical, engineering, computer, and social sciences. Therefore, collaborations are essential to tailor a suitable innovation and meet the medical need. Finally, this study found that multi-sectoral collaboration is important on scaling up DHIs. However, if we look at disruptive innovations by start-ups, it is the strong value propositions which made them survive the battle with external controversies. In conclusion, there may not be a single top-down approach that could instantly enable DHIs. Nonetheless, the process of mapping the users’ interests can generate plausible approaches that could promote the adoption of DHIs.

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11. Appendices

Appendix 1. Interview guide

A1.1 Overview

a. The interview is a semi-structured, qualitative interview.
b. Target: 8-20 physicians to be interviewed.
c. The interview is conducted by the researcher and recorded with consent.
d. General rule: open questions.
e. The information about the study would be sent in advance to the interviewee. The information would also be explained before the interview.

A1.2. Interview structure

a. Briefing/introduction
   1) Introduction to the researcher.
   2) Purpose of the study.
   3) Information and consent, including the use of the recorder.
   4) Confidentiality.

b. Consent
   1) Consent form would be provided in advance to the interviewee in a print or electronic form.
   2) To be signed by the interviewee or verbally agreed.

c. Interview questions
   1) Please tell me about your profile as a doctor as well as your specialities.
   2) What conditions of patients do you take care regularly?
   3) What are the insurances that reimbursed in your practice?
   4) What are the challenges of managing diabetes patients?
   5) How do you define successful diabetes care?
      - Is there any specific KPIs from payers (e.g. BPJS *Kesehatan* or private insurance)?
   6) Please tell me about your experience of using information technology in clinical practice.
   7) How do you think information technology can help to address challenges in diabetes management?
   8) What are the preventions and promotions program for chronic diseases patients that is available in your clinic?
      - Do you think digital health can help to improve those programs?
      - Why or why not?

9) [*Researcher explains about remote patient monitoring*] What do you think about this type of digital health interventions?
    - Do you think this is applicable to be implemented in your practice?
    - Why or why not?
10) What are the factors that motivate you to adopt digital health interventions?
    - Examples: Preferred types of incentives?
11) What are the factors that impede you to adopt digital health interventions?
    - Examples: Infrastructure? Regulations?
12) Do you have any other comments or anything to add?

d. Closing remarks

1) Researcher's contact details.
2) Ask reference of another potential interviewee (s).
3) Keep in touch for possible future study.

Appendix 2. Information and consent form

A2.1 Explanation sheets for prospective subjects

Lembar Penjelasan Kepada Calon Subjek

Saya, **dr. Gusti Adintya Putri**, kandidat **Master of Medical Sciences, Karolinska Institutet, Sweden**, akan melakukan penelitian dengan judul *"Digitalizing Diabetes Care: Challenges and Opportunities in the Indonesia Healthcare"* atau dalam Bahasa Indonesia: "**Layanan Diabetes Digital: Tantangan dan Peluang pada Layanan Kesehatan Indonesia**". Penelitian ini disponsori oleh Brighter AB, perusahan teknologi kesehatan Swedia.

Saya akan memberikan informasi kepada Bapak/Ibu/Saudara mengenai penelitian ini dan mengundang Bapak/Ibu/Saudara untuk menjadi bagian dari penelitian ini.

1. Tujuan penelitian:
Penelitian ini bertujuan untuk mempelajari apa saja tantangan dan peluang dari implementasi teknologi informasi dalam perawatan diabetes di layanan kesehatan Indonesia.

2. Partisipasi dalam penelitian:
Penelitian ini akan melibatkan sekurang-kurangnya 8 (delapan) subjek. Jika Bapak/Ibu/Saudara bersedia untuk berpartisipasi dalam penelitian ini, Bapak/Ibu/Saudara akan diwawancara selama kurang lebih 30 menit seputar pengalaman Bapak/Ibu/Saudara menggunakan teknologi informasi dalam perawatan diabetes. Wawancara ini akan direkam dengan ijin Bapak/Ibu/Saudara dan rekaman hanya digunakan untuk kepentingan penelitian ini.

3. Alasan memilih Bapak/Ibu/Saudara:
Bapak/Ibu/Saudara dipilih menjadi subjek penelitian ini karena Bapak/Ibu/Saudara merupakan seorang dokter umum atau dokter spesialis penyakit dalam, terlibat dalam perawatan pasien diabetes, dan familiar dengan penggunaan teknologi informasi dalam pelayanan kesehatan.

4. Potensi bahaya:
Jika ada pertanyaan yang menimbulkan ketidaknyamanan dalam penelitian ini, Bapak/Ibu/Saudara boleh menolak untuk menjawab pertanyaan tersebut. Tidak ada potensi risiko dan bahaya dalam berpartisipasi di penelitian ini.

5. Manfaat:
Hasil penelitian ini dapat digunakan sebagai referensi Bapak/Ibu/Saudara dalam mengembangkan penggunaan teknologi informasi di Puskesmas/Klinik Bapak/Ibu/Saudara untuk meningkatkan pelayanan kesehatan yang prima, terutama dalam perawatan diabetes.

6. Kerahasiaan:
Semua data yang dikumpulkan dalam penelitian ini akan dijaga kerahasiaannya. Informasi tentang identitas Bapak/Ibu/Saudara akan disimpan secara aman dengan proteksi kata sandi. Hanya peneliti utama yang dapat mengakses dokumen tersebut. Presentasi hasil penelitian

dalam pertemuan ilmiah / konferensi dan publikasi dalam jurnal ilmiah tidak akan mencantumkan nama Bapak/Ibu/Saudara.

7. Hak untuk menolak dan mengundurkan diri
Bapak/Ibu/Saudara tidak harus berpartisipasi dalam penelitian ini bila tidak menghendakinya. Bapak/Ibu/Saudara harus paham bahwa walaupun Bapak/Ibu/Saudara menyetujui untuk berpartisipasi, Bapak/Ibu/Saudara berhak untuk mundur dari penelitian ini hingga 1 Mei 2020.

Jika Bapak/Ibu/Saudara menolak untuk berpartisipasi atau mundur dari penelitian ini, keputusan tersebut tidak akan mempengaruhi hubungan Bapak/Ibu/Saudara dengan saya.

8. Informasi tambahan
Jika Bapak/Ibu/Saudara memiliki pertanyaan lebih lanjut seputar penelitian ini, dapat menghubungi saya, Gusti Adintya Putri, melalui kontak berikut ini:
E-mail: gusti.adintya.putri@stud.ki.se
Telepon: +62 (0) 812 8519 5500

A2.2 Consent form to participate in the research

Lembar Persetujuan Keikutsertaan dalam Penelitian

Semua penjelasan tersebut telah disampaikan kepada saya dan semua pertanyaan saya telah dijawab oleh **dr. Gusti Adintya Putri.** Saya mengerti bahwa bila memerlukan penjelasan, saya dapat menanyakan kepada **dr. Gusti Adintya Putri.**

Sertifikat Persetujuan (*Consent*)	
Saya telah membaca semua penjelasan tentang penelitian ini. Saya telah diberikan kesempatan untuk bertanya dan semua pertanyaan saya telah dijawab dengan jelas. Saya bersedia untuk berpartisipasi pada studi penelitian ini dengan sukarela. _____ Nama subjek/wali _____ Tanda tangan peserta studi Tanggal_____ hari/bulan/tahun	Saya mengkonfirmasi bahwa peserta telah diberikan kesempatan untuk bertanya mengenai penelitian ini, dan semua pertanyaan telah dijawab dengan benar. Saya mengkonfirmasi bahwa persetujuan telah diberikan dengan sukarela. Gusti Adintya Putri Nama peneliti/peminta persetujuan _____ Tanda tangan peneliti/peminta persetujuan Tanggal_____ hari/bulan/tahun

Informasi Peneliti:

Peneliti Utama: **Gusti Adintya Putri, dr.**
081285195500
gusti.adintya.putri@stud.ki.se

Appendix 3. Analysis table

Table 4. An example of meaning units, condensed meaning, code, subthemes, and themes of the thematic analysis. Adapted from Graneheim (49).

Source	Meaning Units	Condensed meaning	Code	Subthemes	Themes
IV 008	*"However, there are issues behind them (digital health interventions), whether the regulation or the medical decision that was guided by the internet will have power in law. Then, what if there are wrong decision and there are effects from and to the patient."*	We need to clarify the legality of IT-based medical decision.	The need for regulation	Barriers to adopt	Physicians' perception

Appendix 4. Ethical declaration - LIME

Declaration on ethics in relation to master thesis projects at LIME

This declaration needs to be attached when submitting the project plan for master theses in programmes where LIME is the responsible department, i.e. the following Master's Programmes:

- Bioentrepreneurship
- Health Economics, Policy and Management
- Health Informatics

Preliminary project title:
Digitalizing Diabetes Care: Challenges and Opportunities from Indonesian Healthcare.

Master student
Name: Gusti Adintya Putri
Programme: Master Programme in Bioentrepreneurship
Email address: gusti.adintya.putri@stud.ki.se

Main supervisor
Name: Madelen Lek, PhD
Affiliation: Programme director of Master in Bioentrepreneurship programme, Karolinska Institutet
Email address: madelen.lek@ki.se

A summary of the master thesis project (max 300 words):
Indonesia is ranked the 7th country with highest diabetes cases, with the International Diabetes Federation (IDF) estimation of 10.7 million cases in adults (20-79 years). Trends predicted that the numbers would increase in the upcoming years, which will heavily affect the national health system and society. Challenges within diabetes care in the Indonesian health system includes 1) disparities of healthcare access between region, 2) healthcare professionals (HCPs) distribution, 3) availability of treatments, 4) patient's literacy in diabetes, and 5) change in demographic and increased prevalence of obesity.

Information and communication technology have potentials to address the unmet health needs within diabetes care through digital health interventions (DHI). However, little has been studied on how to enhance the value delivered. This study will investigate the drivers and barriers of DHI in Indonesian healthcare to overcome the challenges in diabetes management.

This study is a cross-sectional, qualitative study to describe current situations and explain the potential causes. Data would be collected through interviews with physicians who are involved in diabetes cycle of care. Furthermore, the obtained data will be analyzed in a thematic approach. The outcome of the study will provide recommendations on how to address the barriers and enhance the drivers to improve the delivered value in healthcare.

Identify and specify the possible problems of ethical character:
The first potential ethical problems will be the confidentiality of the participants. Since the snow-ball sampling methods are used, therefore participants might know one another. However, the master student will keep the participants' identity anonymously at any level.

The second potential ethical problems will be the objectivity of the data. Since the master student has previous experience as physicians, there might be a potential researcher bias. By this mean, there might be similarities of experience that affect the objectivity the research.

DATA HANDLING and RESULTS REPORT

How will the collected data be stored and protected?
The data will be presented anonymously without jeopardizing the confidentiality of the participants' identity. Documents which contain participants' identity will be stored securely with password protection.

In what way will the integrity of the research respondents be guaranteed when the results of the research will be made public?
All information regarding the participants' identity any traceable documents will be kept secured with a password which only known by the master student. After the final submission, all the information will be deleted.

Do you intend to publish your results in a scientific journal or conference?
Potentially yes. Since there is limited study in this topic, therefore this research will contribute valuable knowledge.

If the project has ethical approval, please indicate the file number of the ethical approval and the name of the Ethics Committée:
The ethics committee, Faculty of Medicine, University of Indonesia – Jakarta, Indonesia
No: KET 350 /UN2.F1/ETIK/PPM.00.02/20

DECLARATION OF CONFLICTING INTERESTS and FUNDING ACKNOWLEDGEMENTS

In the case of research commissioned by an external client, e.g. a company, please specify the external client.
Name: Brighter AB
Contact person: Johan Möller
Contact email: johan.moller@brighter.se

Please specify the relationship between the external client and the main supervisor and/or master's student, e.g. employment relation.
The master student is employed part-time in Brighter AB as Business Development Officer. The job description includes building relationships with stakeholders in Indonesia in order to introduce Brighter's product, Actiste, to the region.

Acknowledge funding arrangements with external clients or other funders (name of the funder and sum of funding)
Brighter AB provides return tickets to Indonesia for the data collection. However, the study will be conducted independently. Brighter AB will not influence any decision regarding data collection, results, and analysis.

Does there exist any other conflict of interest of the master's student or any of the supervisors?
None.

SIGNATURES

Main supervisor/research responsible
Date: 2020-02-25
Signature:

Name in block letters: MADELEN LEK

Master student
Date: 2020-02-05
Signature: Gusti Adintya

Name in block letters: GUSTI ADINTYA PUTRI

Appendix 5. Ethical clearance - FMUI

UNIVERSITAS INDONESIA
FAKULTAS KEDOKTERAN

Gedung Fakultas Kedokteran UI
Jl. Salemba Raya No.6, Jakarta 10430
PO.Box 1358
T. 62.21.3912477, 31930371, 31930373, 3922977, 3927360, 3153236
F. 62.21.3912477, 31930372, 3157288
E. humas@fk.ui.ac.id, office@fk.ui.ac.id
fk.ui.ac.id

Nomor : KET-350 /UN2.F1/ETIK/PPM.00.02/2020

KETERANGAN LOLOS KAJI ETIK
ETHICAL APPROVAL

Komite Etik Penelitian Kesehatan Fakultas Kedokteran Universitas Indonesia dalam upaya melindungi hak asasi dan kesejahteraan subjek penelitian kedokteran, telah mengkaji dengan teliti protokol penelitian yang berjudul:

The Ethics Committee of the Faculty of Medicine, University of Indonesia, with regards of the Protection of human rights and welfare in medical research, has carefully reviewed the research entitled:

"*Digitalizing Diabetes Care: Challenges and Opportunities in the Indonesia Healthcare* Layanan Diabetes Digital: Tantangan dan Peluang pada Layanan Kesehatan Indonesia"

Protocol Number : **20-03-0358**

Peneliti Utama / *Principal Investigator* : **dr. Gusti Adintya**

Nama Institusi / *Name of the Institution* : **Karolinska Institutet**

Lokasi Penelitian / *Site* : **Karolinska Institutet, Stockholm–Sweden**

Tanggal Persetujuan / *Date of Approval* : 23 MAR 2020
(valid for one year beginning from the date of approval)

Dokumen Disetujui / *Document Approved* : **Proposal Penelitian, Versi 01 tanggal 24 Februari 2020**
Lembar Informasi untuk Calon Subjek, Versi 01 tanggal 24 Februari 2020

dan telah menyetujui protokol berikut dokumen terlampir.
and approves the above mentioned protocol including the attached document.

Ditetapkan di / *Specified in* : Jakarta

a.n Ketua
Wakil Ketua

UNIVERSITAS INDONESIA FAKULTAS KEDOKTERAN

dr. Nia Kurniati, M.Sc., Sp.A(K)

** Peneliti berkewajiban
1. Menjaga kerahasiaan identitas subjek penelitian
2. Memberitahukan status penelitian apabila:
   a. Setelah masa berlakunya keterangan lolos kaji etik, penelitian masih belum selesai, dalam hal ini *ethical approval* harus diperpanjang
   b. Penelitian berhenti ditengah jalan.
3. Melaporkan kejadian serius yang tidak diinginkan (*serious adverse events*)
4. Peneliti tidak boleh melakukan tindakan apapun pada subjek sebelum protokol penelitian mendapat lolos kaji etik dan sebelum memperoleh *informed consent* dari subjek penelitian.
5. Menyampaikan laporan akhir, bila penelitian sudah selesai.
6. Cantumkan nomer protokol ID pada setiap komunikasi dengan KEPK FKUI-RSCM.

Semua prosedur persetujuan dilakukan sesuai dengan standar ICH-GCP
All procedure of Ethical Approval are performed in accordance with ICH-GCP standard procedure.