DEVELOPMENT AND VALIDATION OF MEDICAL STUDENTS' DIGITAL HEALTH COMPETENCIES SCALE

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by

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In the name of Allah, the Most Gracious, the Most Merciful

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Segalanya akan aku tempuhi,

Biarpun sejuta duri

Menikam bisa hatiku

Menusuk pilu kalbuku

Akan aku teguh berdiri lagi

 # The end of a chapter #

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LIST OF ABBREVIATIONS

AI	Artificial intelligence
CVI	content validity index
DLC	Digital literacy competence
EFA	Exploratory factor analysis
EHRs	Electronic health records
FVI	face validity index
I-CVI	item-level content validity index
KMO	Kaiser-Meyer-Olkin
mHealth	Mobile health
MS-DHCS	Medical Students' Digital Health Competencies Scale
NHS	National Health Service
PAF	Principal Axis Factoring
PI	Principal Investigator
UMS	Universiti Malaysia Sabah
WHO	World Health Organisation

LIST OF APPENDICES

PEMBANGUNAN DAN KESAHAN SKALA KECEKAPAN KESIHATAN DIGITAL PELAJAR PERUBATAN (MS-DHCS)

ABSTRAK

Kesihatan digital menawarkan pelbagai kelebihan, termasuk peningkatan akses kepada penjagaan, pengurangan kos, kecekapan yang dipertingkatkan, peningkatan kepuasan pesakit dan penjagaan berkualiti tinggi. Oleh yang demikian, kecekapan kesihatan digital pelajar perubatan merupakan bidang penting untuk dikaji memandangkan landskap sektor penjagaan kesihatan berubah secara global. Walau bagaimanapun, tiada instrumen dengan bukti psikometrik kesahan dan kebolehpercayaan menggambarkan kecekapan kesihatan digital yang telah dibangunkan dalam kalangan pelajar perubatan di Malaysia. Oleh itu, kajian ini dijalankan untuk membangun dan menilai kesahihan Skala Kecekapan Kesihatan Digital Pelajar Perubatan (MS-DHCS). Kajian ini telah dilakukan untuk membangunkan dan mengesahkan soal selidik yang terdiri daripada lima peringkat: pengenalan domain, penjanaan item, pengesahan kandungan, pengesahan muka, dan penilaian struktur dalaman. Pengenalpastian domain melalui kajian literatur telah dijalankan oleh pengkaji utama, penjanaan item melalui kajian literatur, pengesahan kandungan melibatkan enam pakar kandungan dan pengesahan muka melibatkan 10 pelajar perubatan Universiti Malaysia Sabah (UMS). Sebanyak 160 borang MS-DHCS 3.0 yang mengandungi 32 item telah diedarkan untuk penilaian struktur dalaman. EFA telah dijalankan dan Principal Axis Factoring (PAF) digunakan sebagai kaedah pengekstrakan dalam EFA. Kebolehpercayaan telah disemak menggunakan nilai *Cronbach Alpha*. Tiga domain telah dikenal pasti untuk MS-DHCS dan 39 item telah dijana untuk MS-DHCS 1.0. Pengesahan kandungan 39 item MS-DHCS 1.0

mendedahkan S-CVI/Ave 0.96 selepas semakan dua pusingan dan pengesahan muka 32 item MS-DHCS 2.0 mendedahkan S-FVI/Ave 0.97 dan MeRS 3.0 diedarkan kepada 160 pelajar perubatan untuk penilaian struktur dalaman. EFA menghasilkan tiga faktor iaitu pengetahuan, kemahiran dan sikap yang peratusan terkumpul varians sebanyak 51.7% hingga 62.6%.Julat untuk pemuatan faktor untuk pengetahuan, kemahiran dan sikap masing-masing ialah 0.61-0.77, 0.69-0.87 dan 0.59 – 0.77. Kebolehpercayaan ketekalan dalaman adalah baik hingga cemerlang dengan *Cronbach Alpha* antara 0.88 hingga 0.92 untuk semua domain. Kesimpulannya**,** 32 item terakhir - MS-DHCS dianggap sah dan boleh dipercayai untuk mengukur daya tahan dalam kalangan pelajar perubatan. Walau bagaimanapun, sebarang percubaan untuk menyamaratakan penemuan kepada pelajar perubatan dalam tetapan yang berbeza harus dilakukan dengan berhati-hati dan kajian pengesahan lanjut perlu dijalankan.

DEVELOPMENT AND VALIDATION OF MEDICAL STUDENTS' DIGITAL HEALTH COMPETENCIES SCALE (MS-DHCS)

ABSTRACT

Digital health offers numerous advantages, including increased access to care, cost reduction, enhanced efficiencies, improved patient satisfaction, and higher-quality care. As a result, medical students' digital health competence is an important area to study as the healthcare sector landscape changes globally. However, no instruments with psychometric evidence of validity and reliability depict digital health skills have been examined among medical students in Malaysia. Therefore, the present study aimed to develop and validate the Medical Students' Digital Health Competencies Scale (MS-DHCS). A study was done to develop and validate a questionnaire that consisted of five stages: domain identification, item generation, content validation, face validation, and internal structure assessment. Domain identification through literature review was conducted by the main researcher, item generation through literature review, content validation involved six content experts and face validation involved 10 medical students from Universiti Malaysia Sabah (UMS). A total of 160 MS-DHCS 3.0 forms containing 32 items were distributed for the internal structure assessment. EFA was conducted and Principal Axis Factoring (PAF) was used as an extraction method in EFA. Reliability was checked using Cronbach Alpha values. Three domains were identified for MS-DHCS and 39 items were generated for MS-DHCS 1.0. Content validation of 39-items MS-DHCS 1.0 revealed an S-CVI/Ave of 0.96 after two rounds review and face validation of 32-items MS-DHCS 2.0 revealed an S-FVI/Ave of 0.97 and MS-DHCS 3.0 were distributed to 160 medical students for internal structure assessment. EFA yielded three factors namely knowledge, skills and

attitudes which cumulative percentage of variance of 51.7% to 62.6%. The range for factor loading for knowledge, skills and attitudes were 0.61-0.77, 0.69-0.87 and 0.59 – 0.77, respectively. The internal consistency was good to excellent with Cronbach's alpha ranging from 0.88 to 0.92 for all domains. In conclusion, the 32 items – MS-DHCS is deemed valid and reliable to measure resilience among medical students. However, any attempt to generalize the findings to medical students in different settings should be done with cautious and further validation study need to be carried out.

CHAPTER 1

INTRODUCTION

1.1 Overview

Chapter one introduces the study's background which discusses the importance of digital health technology and the need for digital health competency skills among medical students. The next sub-topic outlined the study rationales, research questions, general objective, and specific objectives of the study and operational definitions. This chapter finishes with a summary for Chapter 1.

1.2 Background

In recent decades, digitalization has become a worldwide phenomenon marked by the extensive use and incorporation of digital technologies in different industries, including healthcare. The rapid progress in technology, especially in computing, telecommunications, and data storage, has been the main driver of this digital transition (Istepanian et al., 2022).

Some key aspects of digitalization in healthcare include electronic health records (EHRs), telemedicine, artificial intelligence (AI), digital imaging and diagnostics, mobile health (mHealth) and wearable devices (WHO Guideline: Recommendations on Digital Interventions for Health System Strengthening: Evidence and Recommendations, 2022).

Recent scoping review showed that digitalization in healthcare is associated with positive outcomes for both healthcare systems and individual patients. By leveraging

digital health technologies, healthcare providers can enhance patient safety, efficiency, and satisfaction, ultimately leading to better overall quality of care (Huter et al., 2020).

Medical schools play a pivotal role in preparing future physicians and ensuring that they are equipped with the necessary knowledge and skills to leverage digital health tools effectively. Hence, medical schools should incorporate digital health education into their curricula, ensuring that students receive comprehensive training on the principles, applications, and potential impact of digital health technologies in clinical practice. Additionally, medical students should have opportunities to gain practical experience with digital health technologies during their clinical rotations and clerkships. This hands-on exposure allows students to understand how these tools are used in real-world healthcare settings, interact with patients through telemedicine platforms, and navigate electronic medical records systems.

It is crucial to provide training and education to medical students in order to enhance their digital competence for various reasons. The increasing utilisation of digital technology in healthcare is causing a significant transformation in the tasks and responsibilities of the health workforce. This transformation highlights the urgent need for capacity building and ongoing professional development. As an illustration, a recent evaluation requested by the United Kingdom Secretary of State for Health and Social Care (known as the Topol Review) revealed that in the next twenty years, most positions in the National Health Service (NHS) will involve digital aspects (The Topol Review — NHS Health Education England, 2019). Furthermore, the significance and capacity of remote care have been highlighted in recent times due of the COVID-19 pandemic. Virtual consultation devices and electronic systems are essential instruments utilised for the

diagnosis and treatment of patients with suspected COVID-19 infections, as well as other infections (Lee et al., 2021). Furthermore, despite the perception that the current and upcoming cohort of practitioners are proficient in digital technology due to their status as "digital natives," surveys conducted among healthcare workers indicate that they desire additional training in this area (Car et al., 2021).

A valid measurement of digital health competencies skills is necessary to examine the suitable skills for medical students. However, no study has developed digital health competencies skills needed which include knowledge, skills and attitudes among medical students in Malaysia. Therefore, it has become critical to develop these skills among medical students in Malaysia.

1.3 Study Rationales

In recent decades, advancements in technology have resulted in the extensive digitization of several job duties in healthcare settings and the World Health Organisation (WHO) is utilising digital technologies and health innovation to accelerate the worldwide achievement of health and well-being.

Various factors have been identified as possible challenges to overcome, which include the accessibility of technology, financial resources, and the proficiency of medical students in utilising digital technologies (Whitelaw et al., 2021). Therefore, it is essential for future doctors to possess a wide range of digital health competencies, which include basic skills such as computer and tablet usage, as well as more complex abilities like educating patients on the secure and appropriate utilisation of digital data sources and technology (Poncette et al., 2020).

For digital health to become an essential component of patient treatment, clinicians must actively participate in its application. Hence, it is imperative for medical schools to incorporate digital health into their curriculum and ensure that medical students are well trained in this field (Chandrashekar, 2019). Medical schools play a pivotal role in preparing future physicians and ensuring that they are equipped with the necessary skills and knowledge to effectively utilise digital health tools.

As the healthcare industry continues to evolve, medical students need to be prepared to adapt to emerging trends and technologies. By integrating digital health competencies into medical education, Malaysia can ensure that future healthcare professionals are equipped with the knowledge, skills, and attitudes necessary to thrive in a digitally driven healthcare environment.

Despite the rapidly increasing number of people using digital health in healthcare settings, a scarcity of available evidence has been provided to date to illustrate digital health competencies that have been investigated among medical students. Additionally, most of the digital skills were developed for the non-medical students' populations. Therefore, it has become a critical need to develop digital health competencies among medical students.

1.4 Research Questions

1. What are the items and domainsof Medical Students- Digital Health Competencies Scale (MS-DHCS)?

2. What is the content validity of MS-DHCS?

3. What is the face validity of MS-DHCS?

4. What is the factorial structure and reliability of MS-DHCS?

1.5 Objectives

1.5.1 General Objectives

To develop and validate MS-DHCS

1.5.2 Specific Objectives

1. To determine the items and domainsof MS-DHCS

2. To determine the content validity of MS-DHCS

3. To determine the face validity of MS-DHCS

4. To determine the factorial structure and reliability of MS-DHCS

1.6 Operational Definition

The operational definitions are used to clarify terms and variables that this study refers to. Medical students are individuals who are enrolled in an accredited medical school or program leading to the attainment of a medical degree (e.g., Doctor of Medicine or MBBS). They usually participate in a well-organized educational programme that encompasses preclinical courses, clinical rotations, and supervised clinical training overseen by licensed healthcare professionals. Medical students might be at many points

in their medical education, ranging from the early preclinical years to advanced clinical rotations. However, they have not yet fulfilled the prerequisites for their medical degree or earned the necessary license to practise medicine independently. The medical students intended for this questionnaire are from Universiti Malaysia Sabah (UMS) and are eligible for face validation and internal structure assessment.

Digital health is defined as integration of digital technologies, information, and communication systems in the healthcare industry. It includes a broad array of applications that aim to enhance the provision of healthcare, education, research, and administration by utilising technology (Kim et al., 2023).

Competency is the ability to integrate and apply contextually appropriate knowledge, skills and psychosocial factors (e.g., beliefs, attitudes, values and motivations) to consistently perform successfully within a specified domain (Vitello et al., 2021).

1.7 Summary

In summary, the integration of digital health competencies and skills into medical education in Malaysia is essential to prepare medical students for the evolving healthcare landscape, address healthcare disparities, enhance healthcare efficiency and quality, and ensure global competitiveness in the field of healthcare delivery and innovation. The research is driven by the lack of information and the absence of digital health competency abilities among medical students in Malaysia. Hence, the aim of this study is to develop and validate MS-DHCS.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The chapter on literature review consists of six sub-sections that seeks to provide a comprehensive overview of digital health education for medical students, offering insights into its importance, current landscape, outcomes, competencies, and theoretical underpinnings. The first subsection introduces the readers to digital health followed by the importance of digital health education for medical students in the second subsection. The third subsection will explore the current landscape of digital health education in medical curricula and the outcomes and impact of digital health education for medical students will be discussed in subsection four. The next subsection will discuss the digital health competencies and skills for medical students. The chapter ends with conceptual framework of the study.

2.2 Introduction to Digital Health

Digital health refers to the integration of digital technologies, information, and communication systems in the healthcare industry. It includes a broad array of applications that aim to enhance the provision of healthcare, education, research, and administration by utilising technology (Kim et al., 2023).

Digital health has a broad scope and includes the use of (*What Is Digital Health? | FDA*, 2020)

(a) Wearable devices

Wearable devices are electronic devices that are worn on the body and offer the capability to monitor, collect, and analyse various physiological and health-related information (Gao et al., 2016). It is available in different forms, such as smartwatches, fitness trackers, activity monitors, smart clothes, wearable patches, and health monitoring devices. These gadgets are fitted with sensors and technologies capable of monitoring many factors including heart rate, physical activity, sleep patterns, blood pressure, blood glucose levels, body temperature, and more (Banaee et al., 2013).

(b) Mobile health (mHealth)

mHealth refers to the use of mobile devices, such as smartphones, tablets, and wearable devices, in healthcare delivery, education, research, and administration. It includes a wide range of applications and services that leverage mobile technology to support health-related activities and initiatives (Free et al., 2013).

(c) Telehealth

Telehealth is the use of telecommunications technology, such as video conferencing, mobile apps, and remote monitoring devices, to provide education from a remote location (Ohannessian et al., 2020).

(d) Health information technology

Health information technologies include the utilisation of electronic systems, software applications, and information management tools in several aspects of healthcare, including delivery, teaching, research, and administration. These includes many

technologies that enable the gathering, manipulation, retention, sharing, and examination of health-related data (Adler-Milstein & Jha, 2017).

(e) Telemedicine

Telemedicine is an essential part of digital health that involves providing healthcare services, consultations, and education remotely utilising telecommunications technology. Telemedicine involves the utilisation of telecommunications technology, including video conferencing, mobile applications, and remote monitoring equipment, for the purpose of delivering clinical services, consultations, and education from a distance. Telemedicine allows healthcare professionals to provide medical care to patients remotely, overcoming geographical limitations and improving access to healthcare services (Bashshur et al., 2016).

Much evidence showed that digital health provides the significant impact on transforming healthcare practices, improving patient outcomes, and enhancing healthcare efficiency and accessibility. Digital health technologies facilitate the implementation of cutting-edge healthcare practices, such as telemedicine, remote monitoring, and personalised medicine, that revolutionise the delivery and administration of healthcare services. Telemedicine enables remote consultations and virtual delivery of healthcare, overcoming geographical limitations and enhancing access to medical treatments for patients irrespective of their location. Remote monitoring devices and wearable technologies provide the ongoing monitoring of patients' health parameters, enabling the timely identification of health issues and proactive treatments. Personalised medicine utilises genomic data, health analytics, and predictive modelling to customise medical

treatments and interventions based on the specific traits and requirements of individual patients (Dorsey & Topol, 2016).

Furthermore, digital health treatments have demonstrated the ability to enhance patient outcomes through improved disease management, treatment adherence, and increased patient engagement in healthcare. For instance, the utilisation of remote monitoring and telemedicine allows for prompt interventions and subsequent treatment, resulting in enhanced management of chronic ailments, less hospital readmissions, and improved clinical results (Free et al., 2013). Additionally, mobile health applications and wearable technologies which empower patients to actively participate in the management of their own health. fostering good behaviours, adherence to medicine, and self-care practices (Kruse et al., 2017).

Digital health technologies enhance the efficiency of healthcare delivery by simplifying administrative processes, maximising the use of resources, and lowering healthcare expenses. Telemedicine and virtual care models, such as teleconsultation and remote monitoring, obviate the necessity of face-to-face encounters, thereby diminishing patient and provider inconveniences such as prolonged waiting periods, travel costs, and scheduling clashes (Goldzweig Dr. et al., 2013). Health information technology, such as electronic health records (EHRs) and health information exchanges (HIEs), facilitate the smooth interchange of data, coordination of care, and compatibility between healthcare systems and providers, hence improving the accessibility and continuity of healthcare (Adler-Milstein & Jha, 2017).

2.3 Importance of Digital Health Education for Medical Students

Incorporating digital health education into medical curriculum is essential for providing future healthcare workers with the necessary skills to manage the fast-changing field of healthcare technology and innovation. The healthcare sector is experiencing a swift change driven by progress in digital health technologies such as telemedicine, wearable devices, health informatics, and artificial intelligence (Parish, 2015). Therefore, it is essential for future healthcare professionals to possess the necessary knowledge and skills to properly utilise these technologies in clinical practice, patient care, and health management.

Digital health technologies have significant promise to enhance patient care, improve clinical results, and promote patient engagement and empowerment. Healthcare workers with an advanced knowledge of digital health principles can successfully incorporate these technologies into patient care pathways, resulting in healthcare delivery that is more personalised and efficient (*Global Strategy on Digital Health 2020-2025*, 2021).

Incorporating digital health education into medical curriculum can enhance the effectiveness and long-term viability of healthcare systems by optimising the use of resources, lowering healthcare expenses, and enhancing workflow procedures {Formatting Citation}. Healthcare practitioners with an extensive knowledge of digital health ideas have the ability to promote innovation, enhance quality, and implement evidence-based practices in healthcare organisations.

Comprehensive digital health education should incorporate discussion on ethical and legal factors related to patient confidentiality, data protection, informed agreement, and professional obligations in the use of digital health technologies (Brall et al., 2019). Healthcare practitioners must possess a comprehensive understanding of the moral dilemmas and regulatory frameworks associated with digital health in order to ensure responsible and ethical conduct (Ma et al., 2023).

2.4 Current Landscape of Digital Health Education in Medical Curricula

The inclusion of digital health education in undergraduate medical curriculum is now widely acknowledged as crucial for equipping future medical students with the necessary skills and knowledge to navigate the ever-changing field of healthcare technology and innovation. Several studies have emphasised the importance of integrating digital health education into undergraduate medical curriculum worldwide (Gagnon et al., 2006). The objective of these initiatives is to ensure that medical students possess the essential knowledge and abilities for effectively using digital health technology in clinical practice.

The prevalence, scope, and content of digital health education initiatives vary widely across medical schools, with differences observed in curriculum design, teaching methods, and learning objectives. Digital health education initiatives are becoming increasingly prevalent in medical schools worldwide, driven by the growing importance of technology in healthcare delivery. In a scoping review conducted by Car et al.(2021), it was shown that a wide range of digital health topics are incorporated into medical curricula, including medical informatics, EHR skills, computer literacy, telemedicine,

basic programming and mHealth. The majority of the research were conducted in the United States (Car et al., 2021).

The extent and comprehensiveness of digital health content differ among medical schools. Some medical schools incorporate it into their existing courses (Law et al.,2019; Kern & Fister, 2011; Fernando & Lundley, 2018; Milano et al.,2014) and there are medical schools that offer standalone courses on digital health (Brockes et al., 2017; Law et al., 2019). In some cases, digital health is provided as an elective course (McGlade et al., 2001), while a few schools make it a mandatory component of their curriculum (Silverman et al., 2012).

The course content for digital health in medical education covers a wide range of topics related to using technology in healthcare. This includes teaching first- to fourth-year medical students about electronic health record (EHR) use, basic computer skills for clinical practice, utilising social media platforms for self-directed learning and integrating digital game-based learning into medical education (Ferenchick et al.,2013; Lee at al., 2017; Periera et al.,2018). Additionally, some courses may also include an elective course (Mesko et al.,2015; Gibson & Silverberg., 2000) , computer programming course for medical students (Law et al., 2019) and telemedicine elective course for second- to fourth-year medical students (Brockes et al.,; Bulik & Shokar, 2010).

The majority of the courses employed a blended delivery style, which involved a combination of online modules or offline learning, as well as traditional methods including small group discussions, lectures, and classroom interactions (Blumenthal et al., 2005; Brockes et al., 2017; Law et al., 2019; Burgun et al., 2006).

2.5 Outcomes and Impact of Digital Health Education for Medical Students

Several research have examined the outcome and impact of digital health education on medical students. These studies have provided evidence that digital health education is beneficial in improving knowledge, abilities, attitudes, and preparedness to use digital health technologies in clinical practice.

Research has demonstrated that implementing digital health education programmes results in significant improvements in medical students' understanding and proficiency in diverse digital health subjects, such as EHRs, telemedicine, health informatics, and mobile health applications (Poncette et al., 2020; Seemann et al., 2023; Tsopra et al., 2023).

Car et al. (2019)conducted a systematic review and meta-analysis, which found that digital problem-based learning interventions in health professions education were associated with significant improvements in knowledge acquisition and clinical skills development (Car et al., 2019).

Digital health education can lead to positive changes in medical students' attitudes, perceptions, and confidence levels regarding the use of technology in healthcare. A study conducted by Jebreen et al. (2024) among Palestinian undergraduate medical students showed that digital health education initiatives were associated with increased confidence in using digital health technologies and improved perceptions of their relevance in clinical practice (Jebreen et al., 2024).

Furthermore, digital health education prepares medical students to use technology-enabled healthcare environments and engage in evidence-based practice. A systematic

review conducted by George et al. (2014) to evaluate the impact of online eLearning interventions on health professions students and found that digital learning approaches improved participants' knowledge readiness for using digital health technologies in clinical settings compared to traditional learning (George et al., 2014).

2.6 Digital Health Competencies and Skills for Medical Students

Many studies has been conducted to measure the digital framework, while only one study conducted in Denmark looking at medical students (Khurana et al., 2022), the remaining were looking at different populations such as healthcare professionals (*The Digital Health Capability Framework for Allied Health Professionals | Health.Vic.Gov.Au*, 2022) and middle school students (Yang et al., 2021).

Digital health competencies designed for other professions might not be suitable for medical students due to several key differences in the roles, responsibilities, and required skill sets between healthcare professionals and other fields. Medical students require competencies specifically aligned with clinical practice, patient care, and medical ethics. The digital health competencies for medical students must encompass a deep understanding of clinical workflows, diagnostics, treatment planning, and patient interaction, which are central to their future roles as physicians (McGlade et al, 2001). In contrast, questionnaires designed for other professions might focus on digital competencies relevant to their fields, such as business analytics, project management, or general data handling, which do not necessarily translate to the clinical context (Basilotta-Gómez-Pablos et al., 2022).

Additionally, the application of digital health tools in medicine is often directly related to patient care, such as using electronic health records (EHRs), telemedicine platforms, and medical imaging systems. Competencies for medical students need to reflect the specific requirements of using these technologies safely and effectively in clinical settings (Bashshur et al., 2016). In non-medical fields, digital tools may be used differently, such as for administrative tasks, communication, or general information management. The context and consequences of using these tools differ significantly from the high-stakes environment of healthcare (Yeung et al., 2023).A study conducted by Yang J et al. (2021) in China aimed to establish a framework for digital learning capabilities (DLC) among 3473 middle school students. The literature study, scale validation, and exploratory factor analysis revealed six characteristics of Digital Literacy Competence (DLC): technology use, cognitive processing, digital reading competence, time-management, peer management, and will management. The six dimensions explained 58.66% of the overall variability of the scale. The scale demonstrated a high internal consistency coefficient of 0.94. The findings demonstrated that the created DLC scale is a viable and dependable tool for evaluating the digital learning competency of middle school students. (Yang et al., 2021).

The digital health capacity framework for allied health professionals was formed in 2022 in Victoria, Australia. This framework outlines the essential components of digital health that allied health practitioners need to possess. The framework aims to direct the use of digital health technology and clinical information systems by allied health professionals. It seeks to enhance the coordination of patient care, improve safety and clinical results, and stimulate innovation and research in developing new care models. A

mixed-methods strategy was employed to create and authenticate the abilities, which involved five phases: (i) Doing a literature/scoping review to find pre-existing frameworks. (ii) Conducting interviews by a panel of experts, (iii) Analysis of interview themes using thematic analysis, (iv) Testing and gathering input from users, and (v) Making revisions based on the feedback received. The framework categorises four areas as follows: the digital workplace, digital professionalism, data and informatics, and digital transformation (*The Digital Health Capability Framework for Allied Health Professionals | Health.Vic.Gov.Au*, 2022).

In Malaysia, the Malaysian Qualifications Framework 2.0 (MQF 2.0) is a comprehensive framework that guiding the development, classification, and recognition of education and training programs in Malaysia. It was developed by the Malaysian Qualifications Agency (MQA) and serves as a benchmark for quality assurance in higher education. MQF 2.0 builds upon the original MQF, incorporating updates to reflect the evolving educational landscape and the needs of the 21st century. Recognizing the importance of digital skills in the modern world, MQF 2.0 integrates digital literacy across all levels of qualifications. This includes the ability to use digital tools and technologies effectively, critically evaluate digital information, and apply digital skills in various professional contexts.

The only study that has been conducted among medical students was conducted by Khurana et al from Denmark. This study included two rounds of modified Delphi techniques to determine the topics that should be incorporated into the medical student curriculum. The topics were evaluated by 18 experts, all of whom participated in both rounds of the questionnaire. Out of all three sub-categories, a total of 40 topics, which is

62% of the total, achieved a rating of ≥4, as per the established cut-off value. Out of the knowledge topics selected in the scoping review, 22 of them reached a minimum score of 4 in the second set of surveys. The items included overview of health data infrastructures, telehealth, biomedical sensors, clinical decision support systems, AI, bioinformatics, big data, wearables devices and many more. Out of the skill themes included, five met the predefined cut-off of ≥4 in the second round of questions. The items included working with support systems, using EHR, conducting telemedicine and applying digital diagnostic devices. Out of the digital health themes on attitudes, twelve passed the predetermined threshold of ≥4 in the second set of questions. The items included digital ethics, impacts the patient-provider relationship, acknowledgment of EHR, recognition of algorithm bias, acknowledgment of data overload (Khurana et al., 2022).

2.7 Conceptual Framework

Subsection 2.6 provides an overview on the digital health competencies among medical students. As we notice that only one study was conducted looking at medical students (Khurana et al., 2022). This study will be used as a conceptual framework to develop digital health skills in Malaysia. By leveraging insights from this study, educators and policymakers can design tailored educational interventions and curricular enhancements to ensure that medical students in Malaysia are equipped with the necessary competencies to thrive in a technology-enabled healthcare environment.

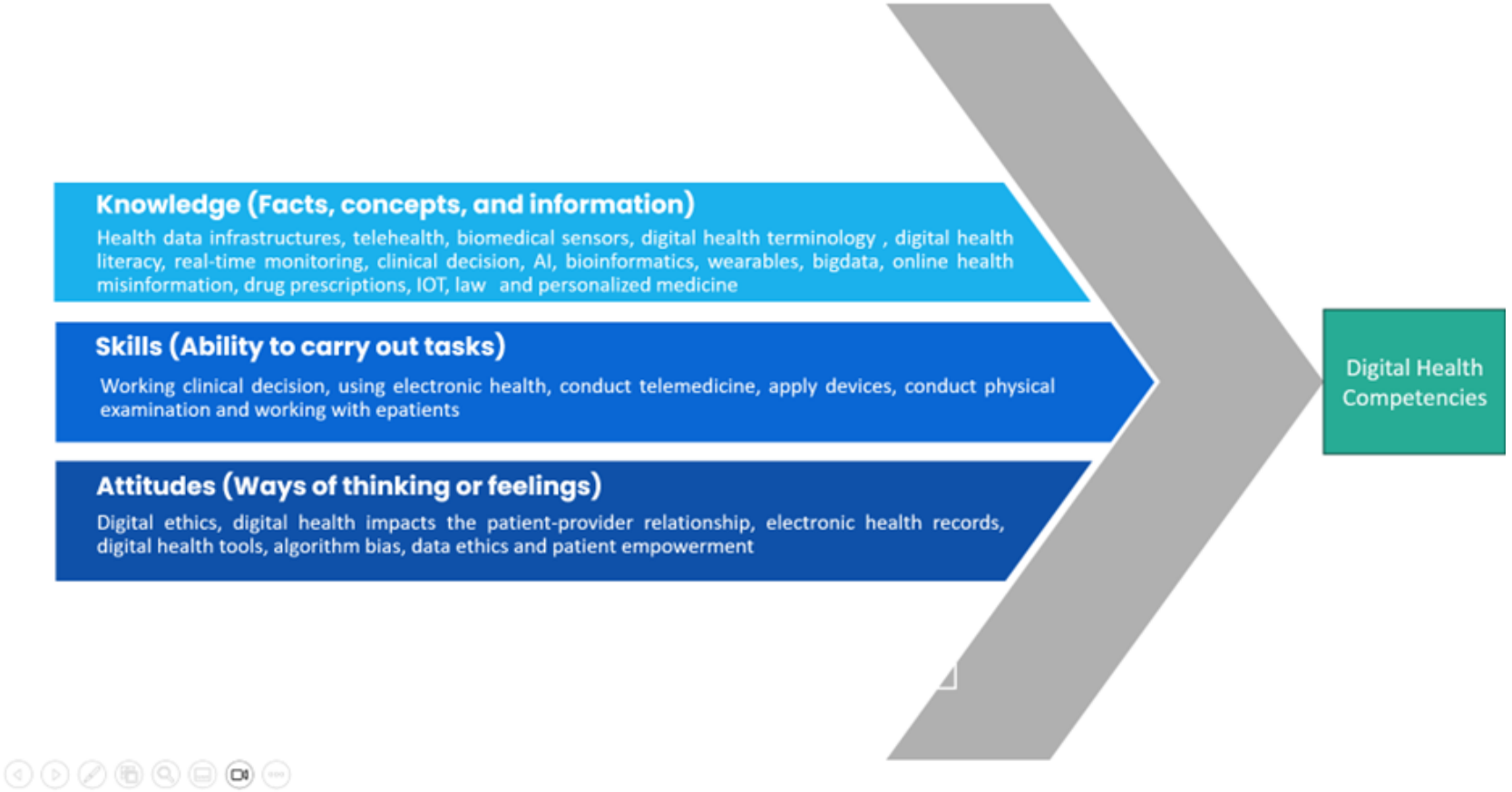

Figure 2.1 Conceptual framework on digital health competency skills among medical students adopted from (Khurana et al., 2022).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents a comprehensive of the research methodology, covering nine subtopics. The nine subtopics encompassed in this study are: introduction, study design, study duration, study population, sampling method, data collection, statistical analysis, ethical issues, and study flowchart. The chapter commences with an overview of the study population, followed by an outline of the study methodology that provides a concise introduction to the five stages involved in developing and validating the questionnaire. Subsequently, a concise overview of the duration of the study and the population being referred to is provided. The source population section presents comprehensive information regarding the rationale behind the sample selection, as well as the specific inclusion and exclusion criteria applied in each phase of the study. It is important to note that different individuals with distinct eligibility criteria were included in each phase.

The sample size calculation incorporates data from previous research to support the selected sample size for the investigation. The sample and subject recruitment procedure elucidates the approach employed to enlist participants for each stage of the investigation. The research tool section provides a comprehensive overview of the instruments used at each stage of the study. This is followed by an explanation of the various data collecting methods employed during the scale development and validation process, along with the justification behind their selection. The statistical analysis part encompasses the methodologies employed to assess the factorial structure and internal consistency of the scale, along with rationales for their

utilization. The ethical considerations were explicitly outlined in Chapter Three, followed by a study flowchart.

3.2 Study Design

The study followed a methodical five-step design process established by Artino Jr et al (2024) (Artino Jr et al., 2014). Artino's methodical, five-step procedure comprises:

i) Conduct literature review

ii) Develop items

iii) Conduct expert validation

iv) Conduct cognitive interview

v) Conduct pilot testing

The study was conducted in two phases: Phase I encompassed the creation of MS-DHCS, which consisted of the initial and subsequent stages. Phase II, on the other hand, focused on verifying MS-DHCS, which entailed the third through fifth stages.

3.3 Study Period

The was conducted from December 2022 until May 2024.

3.4 Study Population

3.4.1 Reference Population

This questionnaire is intended for Malaysian medical students.

3.4.2 Source Population

3.4.2(a) Phase I: Development phase

3.4.2(a)(i) Conduct literature review

A literature review was conducted to identify the domain by the main researcher.

3.4.2(a)(ii) Develop items

The process of generating items for the Development and Validation of MS-DHCS involved doing a review of the literature and having research team meetings with four researchers. This is crucial in order to ensure that all items are clear, comprehensible, and formulated in accordance with the most up-to-date standards in survey design.

The goal of this step was to write items that adequately represent the construct of interest in a language that respondents can easily understand. One important design consideration is the number of items needed to adequately assess the construct. The ideal number of items depends on several factors, including the complexity of the construct and the level at which one intends to assess it. In general, it is good practice to develop more items than will ultimately be needed in the final scale (e.g. developing 15 potential items in the hopes of ultimately creating an eight-item scale), because some items will likely be deleted or revised later in the design process (Gehlbach H et al (2011).

3.4.2(b) Phase II: Validation phase

3.4.2(b)(i) Content validation

Content validation required the participation of a minimum of six content experts who are expert in digital health and currently work as university lecturers in either public or private universities in Malaysia. The selection of experts will be based on the inclusion criteria. listed below.

Inclusion criteria

i) A university lecturer

ii) Currently working in Malaysia public or private university

iii) Has any evidence of expertise in the field of digital health

Exclusion criteria

i) Part of the research team meeting

3.4.2(b)(ii) Face validation

Face validation involved 10 medical students from UMS.

Inclusion criteria

i) Active medical students in UMS

ii) Agree to provide consent for this study

3.4.2(b)(iii) Internal structure assessment

Assessment of the internal structure of MS-DHCS involved 160 medical students from UMS.

Inclusion criteria

i) Active medical students in UMS

ii) Agree to provide consent for this study

Exclusion criteria

i) Involved in the face validation of MS-DHCS

3.5 Sampling Method

3.5.1 Sample Size Calculation

3.5.1(a) Content validation

Following Rubio's recommendations, a minimum of six subject area experts were enlisted via invitation letter for the content validation (Rubio et al., 2003; Yusoff, 2019a).

3.5.1(b) Face validation

Many studies recommend that at least seven to ten respondents are needed for face validation (Hernandez-Garbanzo, 2011; Ibrahim, 2003; Thomason, 2008; Yusoff, 2019b). Hence, 10 medical students were involved in the face validation of items.

No specific number criteria were established for content validation, face validation, or the EFA. Table 4.1 presents the sample size utilised in this study, which fulfils or surpasses the suggested sample size mentioned in the literature.