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# E-Health Research in Southeast Asia: A Bibliometric Review

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**Abstract:** eHealth or digital health innovations expanded tremendously during the COVID-19 pandemic. Innovation and digitalization offer creative solutions to build up a healthy society. The eHealth technologies are quickly taken up by Southeast Asia countries and continue to flourish to alleviate the burden of healthcare challenges. This study is the first review exploring and analyzing the whole literature of eHealth, specifically in the Southeast Asia region. The objective of this study is to document the size, growth trajectory, and geographical distribution of eHealth in Southeast Asia research, identify high-impact authors and documents, explore the intellectual knowledge structure, and analyze the topical trends of the field. The bibliometric analysis was used to analyze a data set of 1405 Scopus-indexed documents between 1976 and 2021. Descriptive analysis, citation, co-citation, and keyword co-occurrence analyses were conducted to gain insights into eHealth in the Southeast Asia knowledge base. The growth rate of literature has rocketed up since 2018, reflecting the significant increase in demand for eHealth in Southeast Asia. Among the eleven Southeast Asian countries, Indonesia, Malaysia, Singapore, and Thailand were the top four countries where the most eHealth-related research was conducted. The intellectual structure of eHealth in Southeast Asia literature comprises four schools of thought (i.e., four groups of similar theoretical perspectives and research interests): (1) analysis and adoption of hospital information system/eHealth records, (2) user intention and acceptance of information technology, (3) technology for healthcare and disease management, and (4) mobile health technology (m-Health). Mobile applications, social networks, the COVID-19 pandemic, patient referral, follow-up, self-care, quality of life, psychology, diabetes mellitus, and hypertension are the recent emerging research themes in the field of study. The eHealth development should consider long-term sustainable management along with the rapid evolution of the field. Additionally, eHealth systems should be holistic and pay attention to technology adoption, data security, and ethical issues involved in medical practices. This bibliometric review delivers reference points for scholars interested in Southeast Asia eHealth, reveals the emerging intellectual structure of this interdisciplinary field, and provides guidance to future research on this domain.

**Keywords:** e-health; bibliometric review; electronic health; telemedicine; telehealth; digital health



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## 1. Introduction

In the contemporary era, the world has been disrupted by digital technologies. With no exception in the healthcare industry, innovation and digitalization deliver promising solutions to build up a healthy society by fostering equitable, affordable, and universally accessible healthcare [1,2]. Since 2005, the World Health Organization has encouraged nations to use digital health strategies in their health system [3]. With the proper implementation, digital health technologies can escalate the progress toward Universal Health Coverage and health-related Sustainable Development Goals [2,4].

The term "eHealth" denotes the digital health technologies or the use of emerging information and communication technologies (e.g., Internet, artificial intelligence, big data, mobile device) to improve health and the healthcare system [5–7]. There are several subdomains under its broad scope, including telehealth, telemedicine, mHealth, wearable healthcare devices, health information technologies, and robotic and personalized

medicine [8,9]. These technologies have significantly dominated the health system by connecting patients, families, and healthcare providers and enhancing patient-centered care delivery. The world is also receiving help from eHealth to solve the increasing healthcare demand by the aging global population.

Moreover, the recent COVID-19 pandemic highlighted the benefits of telemedicine and other forms of e-medical care [10,11]. Given the rapid spread of the coronavirus from person to person during the COVID-19 pandemic, hospitals are overwhelmed with virus-infected patients. Governments imposed large-scale lockdowns across the countries to reduce social contact and further spread the virus. However, the news reported that these extensive lockdown measures inflicted the health system as patients cannot easily and timely access the healthcare providers. Thereby, eHealth technologies are mushrooming as they can alleviate the tremendous burden on medical resources and minimize the amount of person-to-person contact required for treatment [12–14].

In Southeast Asia, the enhancement of the eHealth strategy was designated as one of the significant public service priorities by the ASEAN Digital Master Plan 2025 [15]. Southeast Asian countries are increasingly taking up eHealth services. Furthermore, eHealth's implementation fulfills consumers' rising demand for better healthcare services, especially amid the COVID-19 pandemic [16–19].

Although the eHealth market in Southeast Asia has opportunities to prosper in the coming years, there is still a lack of knowledge about the region's types, availability, distribution, and perceptions. Therefore, this bibliometric review fills the knowledge gap about eHealth in the Southeast Asian region by addressing the following research questions:

1. How is research on eHealth in Southeast Asia distributed over time and geographical sources?
2. What authors and documents have evidenced the most significant citation impact in the literature on eHealth in Southeast Asia?
3. What is the intellectual structure of the knowledge base on eHealth in Southeast Asia?
4. What topics have attracted the most significant attention from scholars on eHealth in Southeast Asia over time?

This bibliometric review provides a systematic examination of the body of research conducted on eHealth in Southeast Asia. The study used bibliometric methods to analyze a dataset comprised of 1405 Scopus-indexed articles. The analyzes included in this review are descriptive analysis, citation, co-citation, and keyword co-occurrence analysis to address the proposed research questions.

Several scholars have conducted a bibliometric review on eHealth; however, most of them studied worldwide trends [20–22]. There is a lack of literature focusing on eHealth in Southeast Asia, where the innovation and implementation of digital health are becoming notable [15]. Hence, this review is the first contribution exploring and analyzing the whole literature of eHealth, specifically in the Southeast Asia region.

## 2. Methods

Among different systematic review methods, the bibliometric review was chosen to analyze the knowledge base in eHealth in Southeast Asia [23]. The methodology section describes the procedure for identifying sources for the bibliometric review and the data analysis methods used in the study.

### *2.1. Identification of Sources for the Review*

In social sciences, the Scopus database contains far more comprehensive coverage of relevant journals than PubMed and Web of Science [24–27]. Previous bibliometric reviews on eHealth confirmed that Scopus has better coverage of sources [7,20], making it a suitable choice for the review of research on eHealth in Southeast Asia.

Keywords were carefully chosen to cover eHealth's field in Southeast Asia countries. The operator "AND" was used between the keywords for eHealth and the keywords for the Southeast Asia countries to ensure both terms are present in documents. Additionally, some

exclusion was also performed by using the operator "AND NOT" to limit the search. The articles focusing on the mobilization of healthcare delivery or the articles in non-Southeast Asia countries did not appear in the data. The search terms used to identify in article title, abstract, and keywords are as follow: "e*health" OR "electronic health" OR telemedicine OR "tele*health" OR "digital health" OR "m*health" OR robotic OR "health informatics" OR "wearable" OR "e*pharmacies" OR "electronic pharmacies" OR "artificial intelligence" OR "information system" AND "Viet nam" OR Vietnam OR Myanmar OR Burma OR Thailand OR Malaysia OR Singapore OR Laos OR Indonesia OR Brunei OR Philippines OR Cambodia OR Timor OR "southeast asia" OR "south east asia" OR asean AND health OR medical AND NOT "mobile clinic" OR "mobile unit" OR veterans.

The PRISMA (Preferred Reporting Items of Systematic Reviews and Meta-Analyses) was adopted [28] to guide the search for documents, and the steps are shown in Figure 1. The keywords mentioned above were searched in the Scopus database, which yielded 2647 documents. The types of documents were limited to journal articles, reviews, and conference papers in the English language. The review duration is from 1975 (i.e., the first publication in the study field) to the end of 2021.

In the next step, the screening process was carried out manually to exclude the irrelevant documents and duplicated items in Scopus. The inclusion criteria were: (1) the documents related to digital health technologies or the use of emerging information and communication technologies (e.g., Internet, artificial intelligence, big data, mobile device) to improve health and the healthcare system; (2) the studies that were conducted in Southeast Asia countries or the review focused on Southeast Asia countries (Myanmar, Thailand, Malaysia, Singapore, Laos, Indonesia, Brunei, Philippines, Cambodia, and Timor Leste). The exclusion criteria were: (1) the hospital information system (subdomain of eHealth) was mentioned only for data extraction in the methodology section; (2) the documents not related to eHealth in Southeast Asia [29,30]. After the screening process, 1405 documents remained in the final review database (Figure 1).

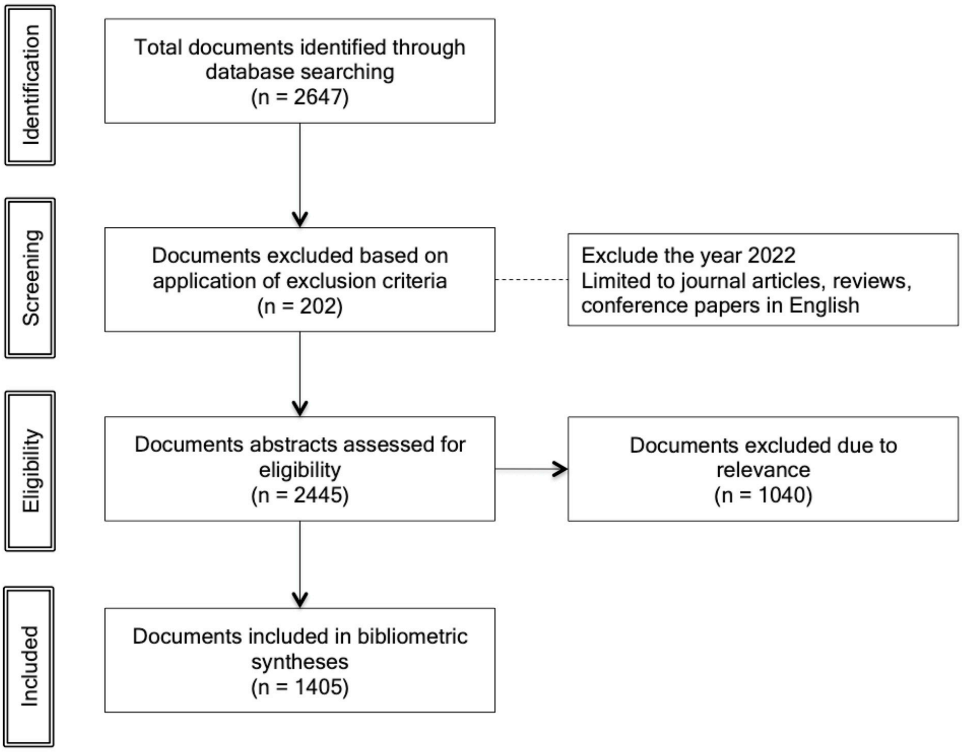


**Figure 1.** PRISMA flow diagram detailing steps in identifying and screening sources (Adapted from Moher et al., 2015 [28]).

### *2.2. Data Analysis*

Bibliographic data related to the 1405 documents (such as authors, affiliations, titles, citations, etc.) were exported and saved. The file was uploaded into the VOSviewer software (version 1.6.17). The VOSviewer software is commonly used for bibliometric analysis [31]. Another copy of the file was saved in Excel for the next stage of the bibliometric analysis. Descriptive statistics were created to describe the landscape of eHealth in the Southeast Asian knowledge base. The advanced bibliometric analyses (e.g., the citation and co-citation analysis and keyword co-occurrence analyses) were conducted in the VOSviewer software.

## 3. Results

This section describes the findings from the bibliometric analysis of the literature on eHealth in Southeast Asia. The section is organized into four parts to address the research questions sequentially.

### *3.1. Analysis of the Descriptive Trends of the Literature on eHealth in Southeast Asia*

A total of 1405 Scopus-indexed publications were found between 1976 and 2021, showing a significant accumulation of documentation in this field. Figure 2 presents the evolution of publications. The literature slowly grew before 2007, with yearly publications below 20 documents. After that, the annual publication growth rate increased to 4%, and the growth of eHealth literature in Southeast Asia took off in 2018 with a yearly publication growth rate of 13%. The number of publications between 2018 and 2021 accounted for over 50% of the total publications. These findings show the rapidly growing literature in the last four years. The increase in scholarly interest in eHealth in Southeast Asia countries could be due to the development of digital technologies [32], high-speed Internet, and mobile phone technologies in this region [33]. Recent public disease outbreaks (COVID-19) also accelerated the growth of eHealth literature in the Southeast Asian area [16–19].

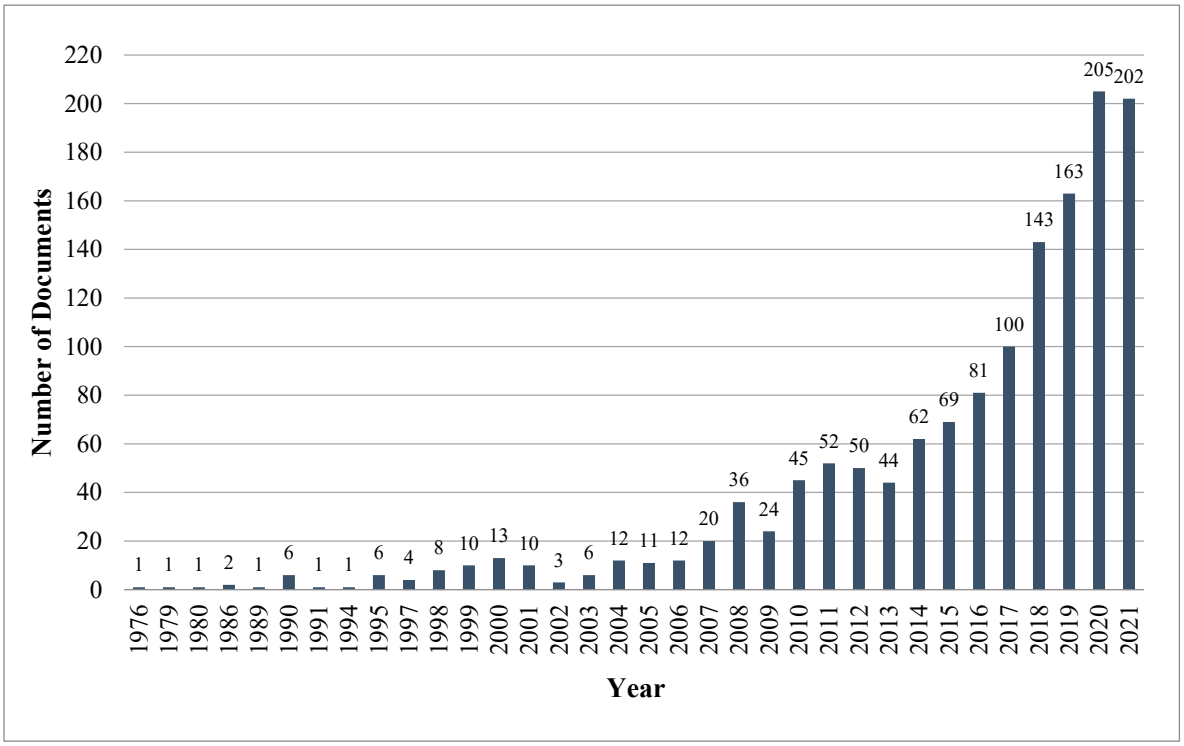


**Figure 2.** Evolution of publications on eHealth in Southeast Asia, 1975–2021 (N = 1405).

The data trend in Figure 3 shows that the field was interested in by scholars worldwide. The top authorship countries were Indonesia (299 documents), Malaysia (299 documents),

Singapore (235 documents), Thailand (213 documents), and the United States (182 documents). The combination of publications from scholars in these five countries accounted for more than 50% of the total publications in the Scopus-indexed knowledge base. The publications were categorized based on the location of the research (Figure 4). It confirms that eHealth in Southeast Asia research was conducted mainly in Indonesia, Malaysia, Singapore, and Thailand. According to Erh (2021), these four countries have a highly developed digital economy in Southeast Asia [33]. On the contrary, several published research carried out in Laos, Brunei, and Timor-Leste were notably low.

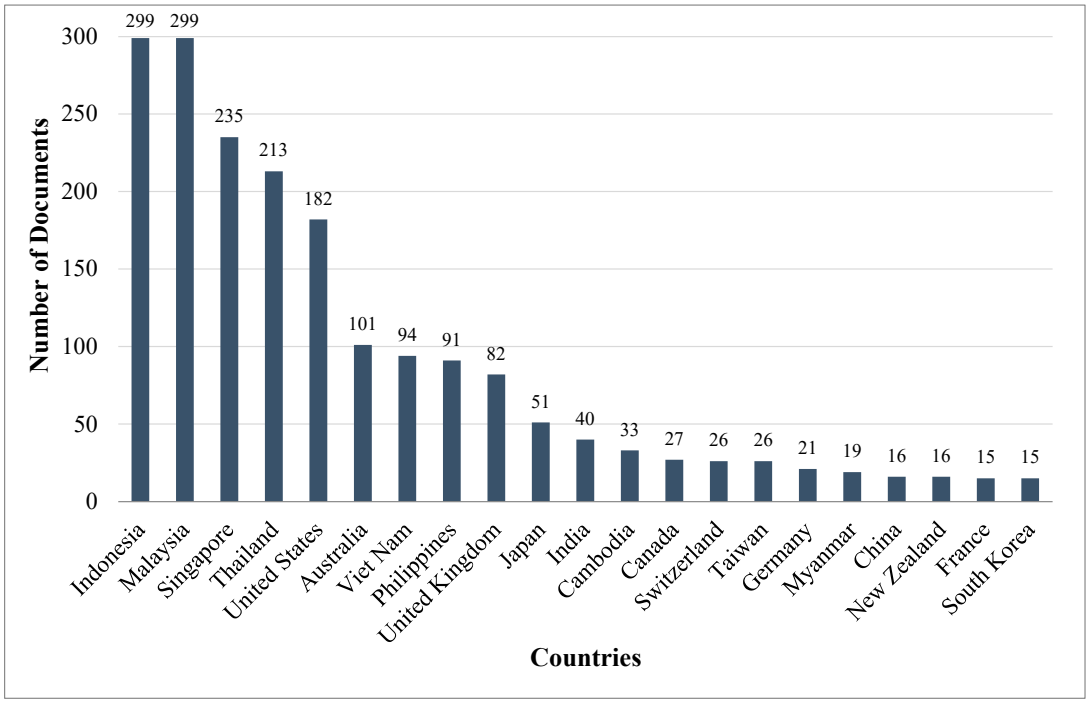


**Figure 3.** Geographical distribution of authorship on eHealth in Southeast Asia literature (N = 1405).

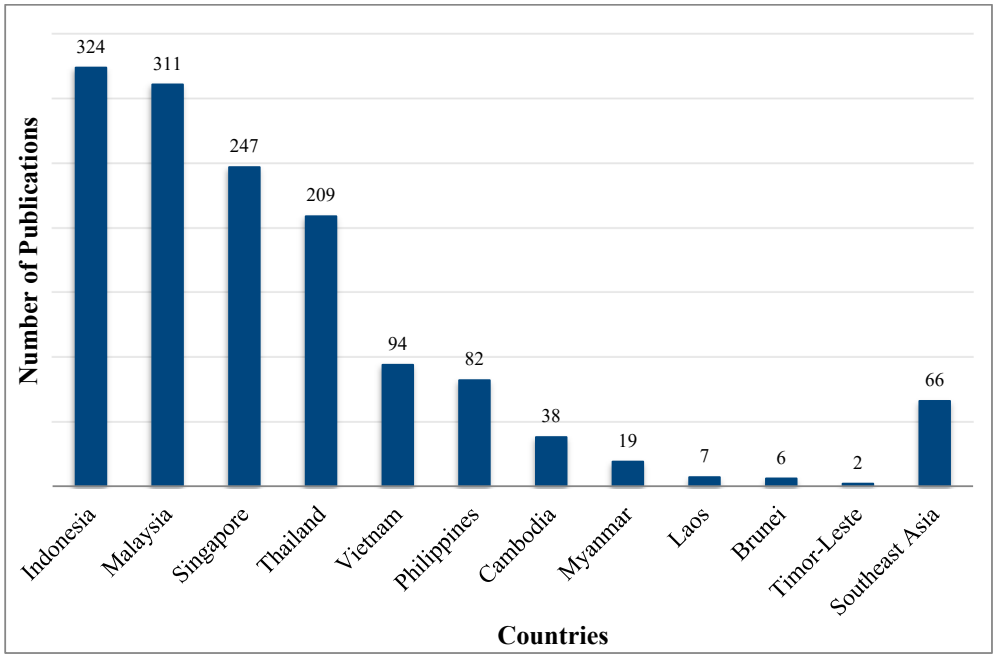


**Figure 4.** Distribution of publications in Southeast Asia countries on eHealth literature (N = 1405).

### *3.2. Analysis of the Key Authors and Documents on eHealth in Southeast Asia*

This section analyses the scholars and documents in the Scopus-indexed eHealth in Southeast Asia knowledge base. The key authors and documents were identified by the use of citation analysis. Citations counts represent a measure of influence. It is assumed that authors cite documents they consider essential for their work. Therefore, a heavily cited article is regarded as the most critical article in the field. Citation analysis provides information about the relative influence of the publications [23].

#### 3.2.1. Key Authors

Table 1 indicates the highest-impact scholars researching eHealth in the Southeast Asian region, as measured by total Scopus citations. There was a total of 5755 authors listed as authors or co-authors in the review database (not tabled), indicating a large number of scholars are interested in this field of research. Among them, the top highly cited scholars were Pannarunothai (374 citations), Kijsanayotin (373), Speedie (351), Choolani (223), and Ong (222). In the nation column (Table 1), it can be seen that the top highly cited scholars are from Thailand, the United States, and Singapore. According to the geographical distribution statistic, Indonesia was the top publishing country on eHealth. However, no Indonesian scholars were found in the top 20 highly cited scholars list. It reflects that research papers from Indonesia relatively may not significantly influence other scholars in this field. Interestingly, the scholars from non-Southeast Asia countries, the United States, and the United Kingdom had high citations since they collaborated with ASEAN scholars and contributed knowledge on Southeast Asian eHealth.

The topical foci of these authors were distributed across public health informatics, clinical informatics, hospital information system, and m-Health. Scholars focusing on public health informatics wrote about the systematic application of eHealth (e.g., telemedicine, health information system, geographical information system, etc.) in public health practice, research, and learning [34–37]. While public health informatics focused on society and the population as a whole, clinical informatics scholars contributed a body of knowledge, methods, and theories that focus on the effective use of information technology to improve the quality, safety, and cost-effectiveness of individual patient care [38–41].

**Table 1.** Top cited authors on eHealth in Southeast Asia, 1975–2021 (N = 1405).

| Rank | Author | Nation | Documents | Scopus Citation | CPD [a] | Topical Focus |
|---|---|---|---|---|---|---|
| 1 | Pannarunothai, S. | Thailand | 5 | 374 | 75 | Public Health Informatics |
| 2 | Kijsanayotin, B. | Thailand | 9 | 373 | 41 | Public Health Informatics |
| 3 | Speedie, S.M. | US [b] | 4 | 351 | 88 | Public Health Informatics |
| 4 | Choolani, M. | Singapore | 3 | 223 | 74 | m-Health |
| 5 | Ong, M.E.H | Singapore | 10 | 222 | 22 | Public Health Informatics |
| 6 | Nilashi, M. | Malaysia | 5 | 210 | 42 | HIS [d] |
| 7 | Ibrahim, O. | Malaysia | 4 | 209 | 52 | HIS [d] |
| 8 | Tai, B.C. | Singapore | 3 | 208 | 69 | m-Health |
| 9 | Chan, H.C. | Singapore | 2 | 206 | 103 | m-Health |
| 10 | Chang, L. | Singapore | 2 | 206 | 103 | m-Health |
| 11 | Duh, H.B.L. | Singapore | 2 | 206 | 103 | m-Health |
| 12 | Xue, L. | Singapore | 2 | 206 | 103 | m-Health |
| 13 | Yen, C.C. | Singapore | 2 | 206 | 103 | m-Health |
| 14 | Lee, B.R. | US [b] | 4 | 185 | 46 | Clinical Informatics |
| 15 | Kavoussi, L.R. | US [b] | 3 | 183 | 61 | Clinical Informatics |
| 16 | Ahmadi, H. | UK [c] | 4 | 177 | 44 | HIS [d] |
| 17 | Wong, T.Y. | Singapore | 8 | 177 | 22 | Clinical Informatics |
| 18 | Singhasivanon, P. | Thailand | 5 | 171 | 34 | Public Health Informatics |
| 19 | Tan, C.S. | Singapore | 7 | 167 | 24 | Clinical Informatics |
| 20 | Ngo, T.D. | UK [c] | 7 | 146 | 21 | m-Health |

[a] Citations Per Document [b] United States [c] United Kingdom [d] Hospital Information System.

Under the broad scope of eHealth, some scholars were focusing on specific domains such as hospital information systems (HIS). HIS is a comprehensive and integrated information system. Nowadays, IT is widely used to manage hospital administrative, financial, and clinical aspects [42]. Meanwhile, "m-Health", also known as "mobile health technology", was also widely studied by scholars due to the advancement in mobile phone technology [43]. The m-Health technology allows patients to find medical information, manage self-health problems and monitor daily health conditions, promoting community health and wellbeing [44]. eHealth is a broad field in which some scholars study this general area while some focus on a particular subdomain of eHealth.

#### 3.2.2. Key Documents

The key documents analysis on eHealth in Southeast Asia knowledge base (Table 2) also revealed a dominance of scholars from Thailand, Singapore, Malaysia, the United States, and the United Kingdom. Moreover, these documents were published by key scholars in Table 1. There are only two articles with Scopus citations over 100, and the contributors were from Thailand and Singapore. The top 20 highly influencing documents on eHealth in Southeast Asia were primarily empirical (16), followed by review (2) and conceptual (2) papers. The high number of empirical papers could be due to the type of research field (information and computer science). Scholars frequently studied technology development, implementation, and analysis [35,42,43]. Empirical studies are crucial in the information and computer science field because the success of technology is greatly influenced by the acceptance of users and features of the technology, which need to be tested on the ground field.

The top cited studies of technology adoption decisions in Southeast Asia adopted different technology acceptance frameworks such as the Unified Theory of Acceptance and Use of Technology (UTAUT) structural model, technology acceptance model (TAM), technology-organization-environment (TOE) framework and human–organization–environment (HOE) fit model [35,42,43,45,46]. The first two theoretical frameworks, UTAUT and TAM, are the most common theories used at the individual level. They explain the factors influencing a person's behavioral intention to use a particular technology. Using these models, user perception studies in Thailand and Singapore revealed that the perceived usefulness of the technology, friendliness of the technology, social influence to use it, and the technological competence of the users are essential for the successful adoption of the technology [35,43,46]. On the other hand, the technology–organization–environment framework and the human–organization–environment fit model are used to predict the technology adoptions into diverse organizational settings. The factors such as relative advantage, compatibility, security concern, hospital size, staff technical competence, and government policy can influence the organizational adoption of technology, according to studies in Malaysia [42,45]. Knowledge gained from these studies is beneficial to both eHealth policymakers and people who work with health and IT development and implementation projects in Southeast Asia.

**Table 2.** High-impact documents by Scopus citations (N = 1405).

| Rank | Document | Nation [a] | Type of Document | Topical Focus | Scopus Citations |
|---|---|---|---|---|---|
| 1 | Kijsanayotin et al., (2009) [35] | TH [b] | Empirical | Hospital Information System | 343 |
| 2 | S. Lim et al., (2011) [43] | SG [c] | Empirical | m-Health | 126 |
| 3 | Ahmadi et al., (2015) [42] | UK [d] | Empirical | Hospital Information System | 85 |
| 4 | Xue et al., (2012) [46] | SG [c] | Empirical | m-Health | 80 |
| 5 | Lee et al., (1998) [47] | US [e] | Empirical | Telehealth | 80 |
| 6 | Son and Tuan (2016) [48] | VT [f] | Empirical | Data Mining | 74 |
| 7 | Fabrlzio et al., (2000) [39] | US [e] | Empirical | Telehealth | 74 |
| 8 | Ahmadi et al., (2017) [45] | UK [d] | Empirical | Hospital Information System | 71 |
| 9 | Nguyen et al., (2016) [49] | CA [g] | Empirical | Telehealth | 71 |
| 10 | Roffeei et al., (2015) [50] | MY [h] | Empirical | Telehealth | 66 |

**Table 2.** *Cont.*

| Rank | Document | Nation [a] | Type of Document | Topical Focus | Scopus Citations |
|---|---|---|---|---|---|
| 11 | Yeung and Gourlay (2012) [51] | SG [c] | Empirical | Geographic Information System | 65 |
| 12 | Chaikaew et al., (2009) [52] | TH [b] | Review | Telehealth | 65 |
| 13 | Kittayapong et al., (2008) [53] | TH [b] | Empirical | Geographic Information System | 63 |
| 14 | Entwisle et al., (1997) [54] | US [e] | Empirical | Geographic Information System | 60 |
| 15 | Mohan and Yaacob (2004) [55] | MY [h] | Conceptual | Telehealth | 58 |
| 16 | Müller et al., (2016) [56] | SG [c] | Empirical | m-Health | 56 |
| 17 | Miles et al., (2017) [57] | UK [d] | Review | m-Health | 55 |
| 18 | Chib and Chen (2011) [58] | SG [c] | Empirical | m-Health | 54 |
| 19 | Smith et al., (2015) [59] | UK [d] | Empirical | m-Health | 52 |
| 20 | Zaidan et al., (2015) [60] | MY [h] | Conceptual | Telehealth | 52 |

[a] Based on 1st author only [b] Thailand [c] Singapore [d] United Kingdom [e] United States [f] Vietnam [g] Canada [h] Malaysia.

In addition, mobile phone users are growing worldwide, and the healthcare industry uses this new channel to deliver care. Table 2 shows the different uses of m-Health in the healthcare industry. The research by Müller et al., (2018) and Smith et al., (2015) adopted m-Health to provide health education and promotion to improve health outcomes of the community in Malaysia and Cambodia, respectively [21,59]. The review by Miles et al., (2017) demonstrated the application of m-Health to encourage self-healthcare management in chronic diseases in many countries, including Thailand and Singapore [57]. In addition, health professionals can use m-Health for communications and delivering quality healthcare to patients, according to a study in Cambodia by Chib and Chen (2011) [58]. These results align with the worldwide literature review on m-Health that the technology is helpful in health promotion, self-management, medication adherence, and interconnection between personal health [60].

Another topical focus is telehealth, which denotes the use of information technologies to provide healthcare services remotely [47]. The highly cited documents on eHealth in Southeast Asia studied the national telehealth system, telementoring, and new technology development in healthcare [39,47–51,55,61]. Telementoring is also known as telesurgery, whereby an experienced surgeon guides and teaches practicing surgeons new operative techniques utilizing current video technology, medical robots, and telecommunications. It can enhance surgeons' skills, increase patients' access to experienced surgeons, and decrease the likelihood of complications due to inexperience with new techniques [47].

Geographical Information System (GIS) is one of the topical foci among the highly influential papers in eHealth in Southeast Asia. GIS is a computer system that analyses and displays geographically referenced information [52]. Southeast Asia countries are in the tropical region, where tropical diseases such as malaria, dengue, cholera, and yellow fever most commonly occur. National health systems need to be aware of these tropical diseases to reduce public health problems. GIS delivers benefits in monitoring and geographically surveilling these diseases in Southeast Asia countries [52–54].

The above citation analysis provides information about the relative influence of the Southeast Asia eHealth publications. However, it cannot identify the intellectual structure (i.e., networks of interconnections among scholars) [23,62]. Therefore, this study adopted co-citation analysis, and it presents it in the next section.

### *3.3. Intellectual Structure of the eHealth Literature in Southeast Asia*

Co-citation analysis measures the similarity between authors, documents, or journals in the field of study. It refers to the frequency with which two units are cited together. The fundamental assumption underlying this analysis is that the more two items are co-cited, the more likely their content is related [23,63]. By using VOSviewer software, this

bibliometric review conducted author co-citation analysis (ACA) to identify the intellectual structure of eHealth in Southeast Asia.

Table 3 presents the highly co-cited authors in the eHealth in Southeast Asia literature. In addition, Figure 5 illustrates the ACA map by using the VOSviewer setting at a threshold of at least 23 author co-citations, which yielded a display of 86 scholars on the co-citation map. The size of the bubbles indicates the co-citation frequency. The larger the bubble means, the greater the scholars' influence in the field of eHealth in Southeast Asia. The colored clusters represent schools of thought, which are the collection of items with similar theoretical perspectives and research interests. There are four distinct, coherent schools of thought in the literature on eHealth in Southeast Asia: "technology for healthcare and disease management" (red cluster with 39 items), "analysis and adoption of hospital information system/eHealth records" (green cluster with 22 items), "user intention and acceptance of information technology" (blue cluster with 15 items), and "m-Health" (yellow cluster with ten items).

**Table 3.** Highly co-cited authors in eHealth in Southeast Asia.

| Rank | Author | Nation | Co-Citation | Topical Focus |
|---|---|---|---|---|
| 1 | Davis, F.D. | United States | 112 | User intention and acceptance of IT |
| 2 | Venkatesh, V. | United States | 75 | User intention and acceptance of IT |
| 3 | Li, Y.C. | Taiwan | 70 | Technology for healthcare and disease management |
| 4 | Lee, J.Y. | United States | 58 | Technology for healthcare and disease management |
| 5 | Free, C. | United Kingdom | 53 | m-Health |
| 6 | Ajzen, I. | United States | 50 | User intention and acceptance of IT |
| 7 | Hair, J.F. | United States | 46 | Analysis and adoption of hospital information system |
| 8 | Ringle, C.M. | Germany | 45 | Analysis and adoption of hospital information system |
| 9 | Bates, D.W. | United States | 44 | Analysis and adoption of hospital information system |
| 10 | Lee, S.H. | United Kingdom | 44 | Technology for healthcare and disease management |
| 11 | Wang, Y. | Canada | 44 | Technology for healthcare and disease management |
| 12 | Wang, J. | United States | 42 | Technology for healthcare and disease management |
| 13 | Wang, W. | Singapore | 41 | Technology for healthcare and disease management |
| 14 | Zhang, Y. | China | 41 | Technology for healthcare and disease management |
| 15 | Delone, W.H. | United States | US | Analysis and adoption of hospital information system |
| 16 | Sarstedt, M. | Germany | 39 | Analysis and adoption of hospital information system |
| 17 | Zhang, J. | Singapore | 38 | Technology for healthcare and disease management |
| 18 | Li, H. | Finland | 36 | Technology for healthcare and disease management |
| 19 | Li, J. | Australia | 36 | Technology for healthcare and disease management |
| 20 | Zaidan, A.A. | Malaysia | 36 | Analysis and adoption of hospital information system |

The red cluster represents the technology for healthcare and disease management. Scholars associated with this school of thought investigated the factors related to the adoption and management of computer science and technology for health, physical activities, and disease management [64–69]. This is the biggest cluster, and many top co-cited authors (such as Li, Y.C., Lee, J.Y., Lee, S.H., Wang, Y., Wang, J., Wang, W., Zhang, Y., Zhang, J., Li, H., and Li, J.) are involved in this cluster. Studies of authors in this cluster highlighted that adopting eHealth technologies needs financial support and trust, organization structural support, leadership, and knowledge-sharing capacity [64,65,68,69]. These findings provide valuable implications for practitioners and researchers interested in adopting eHealth technologies.

The green cluster researches the "analysis and adoption of hospital information system/eHealth records". Scholars working within this school of thought have studied frameworks for decision-making and adopting the hospital information system (HIS) at the organizational level [45,70–72]. Popular theories by these authors are the DeLone and McLean Model of information systems success [71] and the Technology–Organization–Environment–Human framework [45]. These theories were foundations for adopting hospital information systems research in Southeast Asia. In addition, Hair et al., who intro-

duced multivariate data analysis [73], are also included in this cluster. Due to the centrality of his node position in the cluster, it may be interpreted that scholars frequently adopt this quantitative method in empirical research of hospital information system adoption.

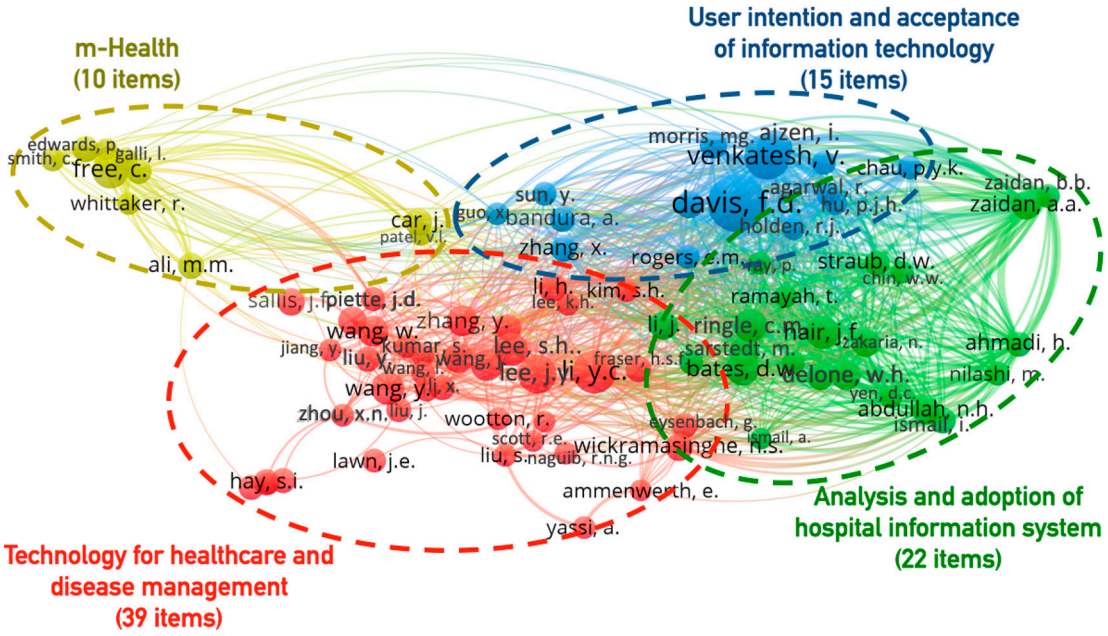


**Figure 5.** Four clusters representing the intellectual structure of eHealth in Southeast Asia (Threshold 23, Display 86 Authors).

The blue cluster studies "the user intention and acceptance of information technology", included scholars such as Davis, Venkatesh, Ajzen, Agarwal, and Fishbein [74–78]. These scholars were linked because their research examines individual users' attitudes, perceptions, and acceptance of IT adoption. Davis and Venkatesh, located in this cluster, were the top two co-cited authors in Table 3. Davis is the pioneer in developing the user acceptance of technology theory [76]. Venkatech collaborated with Davis and colleagues to build the UTAUT model, which is very useful for scholars, policymakers, and technology developers to determine the user acceptance of IT [78]. The findings of the top-cited document in this study also suggested that the UTAUT model could be applied to health technology in Thailand [35].

Finally, the yellow cluster can be termed "m-Health". This group is the smallest of the four schools of thought. However, it has a distinct character because this group of scholars has investigated the use of mobile health technologies or text messaging to deliver health promotion or control public health problems [79–81]. Along with the exponential increase in the number of mobile phone users in both high- and low-income countries, mobile phones are widely used in health information and healthcare delivery [82]. In Southeast Asia, m-Health has been used via text messaging or smartphone applications to remind health service appointments, to deliver messages for medication adherence, to prevent unhealthy activities such as smoking cessation, to assist in monitoring and self-management of chronic disorders such as hypertension and diabetes [82–86].

To summarize, co-citation analysis revealed four major schools of thought involved in the literature on eHealth in Southeast Asia from 1975 to 2021. This result can be used to analyze the evolution of the academic field in future studies.

### *3.4. Topical Foci of the eHealth in Southeast Asia Knowledge Base*

Keyword co-occurrence analysis, also called co-word analysis, identifies key themes and topics within the eHealth in Southeast Asia knowledge base. Co-word analysis frequently identifies co-occurring words in the titles, abstracts, and indexes of documents in

the review database [23]. This analysis would offer insight into broad topical trends within the literature.

Figure 6 shows the density map of the most frequently occurring keywords in the literature: healthcare delivery (316), telemedicine (308), health information system (243), medical information system (164), m-health (162), electronic health record (141), geographical information system (135), public health (124), hospital (120), elderly (115), organization and management (105), and covid-19 (100). These frequently occurring keywords offer insight into the subjects of studies that describe the eHealth in Southeast Asia knowledge base since its emergence in the past four decades.

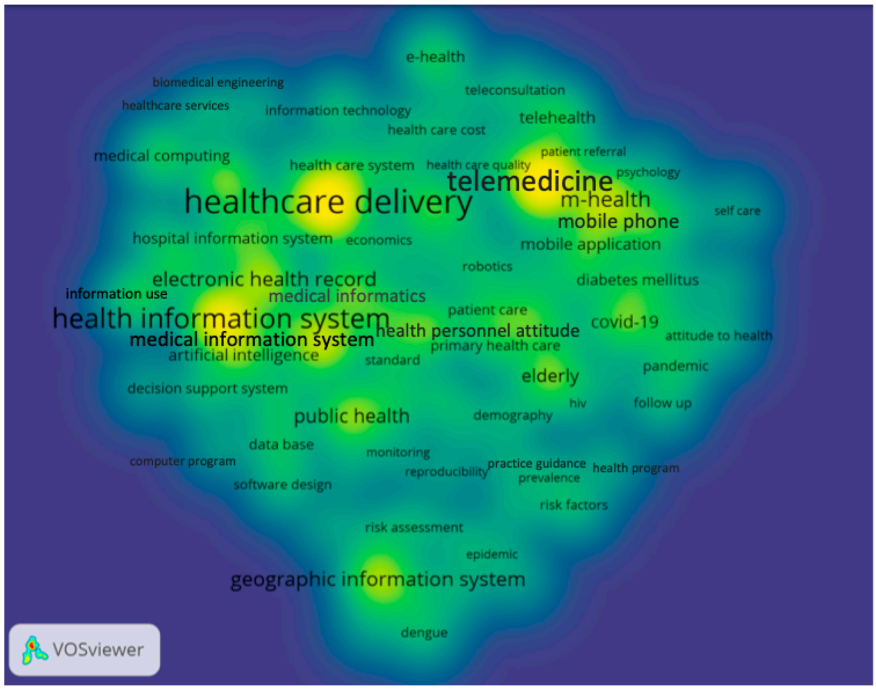


**Figure 6.** Keyword density heat map of the eHealth in Southeast Asia literature, 1975–2021 (Threshold 25 Occurrences, Display 94 Keywords).

In the next step, a temporal co-word map was generated in VOSviewer using a threshold of at least 25 occurrences (Figure 7). It synthesizes the time distribution of keywords based on the document publication date. The difference in colors indicates the different timeframe. Purple/darker bubbles are associated with topics popular in the earlier periods. In contrast, yellow/lighter-shaded bubbles are associated with the most recent topics in this research database.

The biggest bubbles, such as "healthcare delivery", "telemedicine", "health information system", have darker colors, meaning that they were popular keywords in the earlier periods. However, this temporal co-word map also presents recent topics in the eHealth literature. The term "m-Health" is shown in the lighter bubble, and it is a relatively new topic emerging after the year 2018. Recent topics of interest among scholars are keywords such as "mobile application", "social network", "covid-19", "pandemic", "patient referral", "follow up", "self-care", "quality of life", "psychology", "diabetes mellitus", and "hypertension". These findings, thus, confirm that the recent public health outbreak, the COVID-19 pandemic, accelerated the usage and application of new health technology in Southeast Asia, especially mobile health technology.

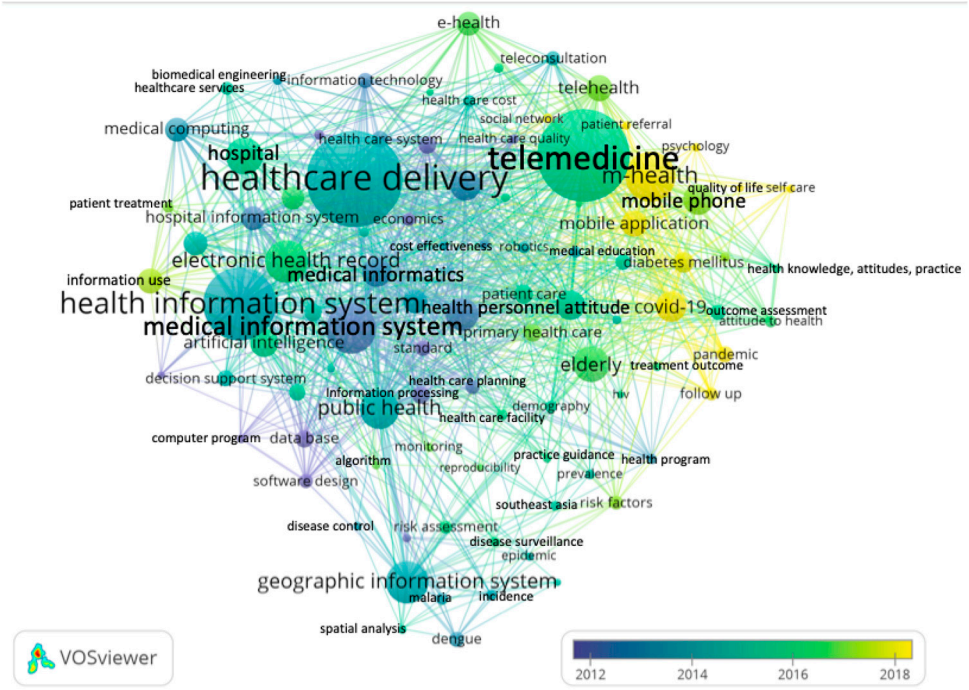


**Figure 7.** The temporal co-word map of the eHealth in Southeast Asia literature, 1975–2021 (Threshold 25 Occurrences, Display 94 Keywords).

After the World Health Organization announced COVID-19 as a global pandemic in 2020, the world was alarmed by its rapid spread. Governments imposed large-scale lockdowns across the countries to reduce social contact and further spread the virus. The effect of this extensive lockdown is the acceleration of death by other diseases such as diabetes mellitus, hypertension, heart attack, and stroke because patients cannot easily and timely access healthcare providers. This issue highlighted the benefits of m-Health, telemedicine, and other forms of e-medical care to support and treat patients [10,11]. m-Health is defined as medical or public health practice supported by mobile devices [87]. m-Health is widely used to ensure patients connect with their healthcare providers virtually. They are integrated into medical treatment, such as daily monitoring of chronic diseases, psychological support for mental health, health promotion, enabling home care, and consequently enhancing the quality of life of people.

## 4. Discussion

This review applied bibliometric analysis to analyze the knowledge base of eHealth in Southeast Asian countries. A total of 1405 Scopus-indexed documents published between 1976 and 2021 were found and included in the bibliometric analysis. This section presents the limitations of the review and the interpretation of the findings.

### *4.1. Limitations*

Firstly, the geographic scope of the review is limited to the Southeast Asian region. Although there are numerous publications on eHealth worldwide, our research includes only publications about eHealth in Southeast Asia. In the reviews of worldwide digital health technology, researchers tend not to focus on particular regions to provide a global trend of eHealth. However, by focusing on the Southeast Asia region, this study provided more nuanced findings and trends of the eHealth specific to this region. For example, the global research trend in eHealth is paying attention to the issues such as privacy, security, and quality improvement [88], while Southeast Asian research in eHealth focuses on user perception and acceptance of information technology, reflecting the difference in trends to different geographical scopes.

Second, the bibliometric review method cannot replace other review methods (e.g., meta-analysis and qualitative literature review). This systematic and quantitative approach to science mapping mainly analyzes the metadata of the documents in the review database. The future review paper should emphasize the quantitative or qualitative synthesis of findings using a systematic review and/or meta-analytic approach. Nonetheless, this study aims to initiate a more comprehensive and robust review of eHealth in Southeast Asia.

Thirdly, the review was conducted only on the articles indexed in the Scopus database. In fact, the literature on eHealth in Southeast Asia was published on various electronic databases such as Pub Med, ProQuest, Science Direct, etc. Despite its wide coverage of documents, the Scopus database may not cover all the existing eHealth literature in Southeast Asia. This limitation was partly addressed by conducting the co-citation analysis of all documents listed in the reference section of the documents included in the Scopus database. This method enabled the identification of related and influential documents not included in the Scopus database.

Lastly, this review includes documents published in the English language to enable closer reading of selected documents, and it excludes documents published in other languages. While the review is focusing on Southeast Asia countries, this might be a potentially significant limitation, as the local language literature of Southeast Asia countries could offer a useful complement to our review.

### *4.2. Interpretation of the Findings*

This study found that the volume of eHealth in the Southeast Asia knowledge base was large, and a total of 1405 Scopus-indexed documents were published between 1976 and 2021. The publications on this topic started slowly, but the growth rate significantly increased over the past decade. It reflects the demand-driven growth by the consumers requiring high-quality healthcare, the aging population, and the recent outbreak of pandemic disease [18,19,89].

The geographical distribution analysis revealed that not only ASEAN scholars but also scholars from all around the world are interested in eHealth literature in Southeast Asia. Indonesia, Malaysia, Singapore, and Thailand are the top four countries scholars use as the research context. It could be due to their more significant advancements in the digital economy compared with other Southeast Asia countries [33]. Future research is recommended to focus more on eHealth in Southeast Asian countries such as Vietnam, Laos, Myanmar, Timor-Leste, Indonesia, Cambodia, and Brunei, where e-health will be increasingly adopted after the COVID-19 pandemic. The insights into the eHealth implementation in one of these countries may benefit other countries in this region and perhaps other developing regions.

The review also identified key authors and documents in the literature on eHealth in Southeast Asia knowledge base. These results (Tables 1 and 2) are valuable for scholars interested in this field as they provide a quick picture of seminal works in that area. Leading authors were mainly from Singapore (Choolani, Ong, Tai, H. Chan, L. Chang, Duh, L. Xue, C. Yen, T. Wong, and C. Tan), followed by Thailand (Pannarunothai, Kijsanayotin, and Singhasivanon), USA (Speedie, Lee, and Kavoussi), Malaysia (Nilashi and Ibraham), and the UK (Ahmadi and Ngo T.D.). Although Indonesian scholars are the most contributors to this database, none of them is found in the top 20 scholars list (Table 2). Scholars from the US and UK are featured in this list because they collaborated with scholars from ASEAN countries to research digital health technologies in the Southeast Asia region.

The key documents of this literature are primarily empirical papers, followed by a few review and conceptual papers. It reflects the empirical-focused nature of the topic since eHealth is also related to the technology field, such as information and computer science. Hence, these empirical studies mainly focus on the innovation process, such as pilot implementation, implementation, and evaluation. Moreover, these empirical studies use quantitative and qualitative methods to analyze their data. However, review articles, which identify and synthesize relevant literature to compare and contrast the findings of

prior studies on eHealth in Southeast Asia, are needed. The review articles can provide readers with a state-of-the-art understanding of the research topics, help identify research gaps and signal future research avenues [90].

The co-citation analysis (Figure 5) found that the intellectual structure of eHealth in Southeast Asia literature comprises four schools of thought: (1) technology for healthcare and disease management, (2) analysis and adoption of hospital information system/eHealth records, (3) user intention, and (4) acceptance of information technology, and m-Health. These findings are consistent with the results from citation analysis because the topical foci are related to hospital information systems, telehealth, and m-Health.

In addition, scholars in the field of eHealth in Southeast Asia are highly influenced by the technology adoption frameworks, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) structural model [78], technology acceptance model [76], and human–technology–organization–environment (HTOE) framework [42]. The first two theoretical frameworks were the most commonly used theories in testing the user perception and acceptance of technology. The HTOE framework analyses the organizational decision-making process and health technology adoption.

Finally, the co-word analysis identified the most frequently occurring keywords in the research database and the recent trend in eHealth in Southeast Asia literature. The most frequently used keywords are, for example, hospital information system (electronic health record), telemedicine, m-Health, and geographical information system related to healthcare delivery and public health problems (Figure 6). The finding suggested that hospital information systems and m-Health keywords appear in every analysis (the citation and co-citation analyses and keyword co-occurrence analyses) performed in our research.

According to the heat map results, hospital information systems are a mature topic in eHealth in Southeast Asia. In contrast, m-Health is an emerging theme driven by the advance in mobile technology and its ease of use for daily health monitoring. According to the World Bank report in 2019, Southeast Asia picked up in digital technology, and it is the leading region regarding Internet usage, primarily via mobile phones [91]. Furthermore, keywords such as psychology, quality of life, self-care, diabetes mellitus, hypertension, and follow-up also recently emerged in the literature. These findings are consistent with previous bibliometric reviews of eHealth in global literature [21,92]. The use of smartphones and wearable devices for application in behavioral change therapy (encouraging physical activity, healthy eating, and self-monitoring) has increased sharply. In addition, the COVID-19 outbreak has highlighted the need for effective eHealth in supporting mental and physical health and in supporting routine treatment visits [10].

## 5. Conclusions

In conclusion, this review is the first contribution exploring and analyzing the literature on eHealth in, particularly in the Southeast Asia region. This bibliometric review uses science mapping, which offers the longitudinal-quantitative perspective by revealing the contributions of the scholars and portraying the dynamic evolution of Southeast Asia eHealth knowledge from a focus on literature 45 years ago to literature today. The findings presented in this review suggest several directions for scholars interested in this discipline.

Firstly, this review identified a geographical imbalance in the Southeast Asia eHealth knowledge base with paucity of eHealth research from Brunei, Cambodia, Laos, Myanmar, Philippines, Timor-Leste, and Vietnam despite these countries also improving in health systems. While the ASEAN is moving forwards with a digital society, this finding stimulates future research interest in studying how these seven countries develop and implement eHealth in their health systems.

Secondly, there is a lack of systematic review papers which critically analyze findings from empirical research on eHealth. Although a bunch of empirical papers provides valuable knowledge in technology innovation and implementation, healthcare providers and policymakers require rigorous conceptual guidance on eHealth. Otherwise, this field will lack a state-of-the-art understanding of the discipline.

Thirdly, citation and co-citation results deliver valuable information for scholars working in this emerging industry. For instance, key authors and document tables could be used to generate an initial "reading list" for new scholars. This would reduce the start-up time required for scholars entering this field of eHealth research. Similarly, the intellectual structure of the Southeast Asia eHealth revealed by the author co-citation analysis reflects the influential conceptual streams of inquiry that have emerged in this field.

Fourthly, eHealth technologies in Southeast Asia are boomed, particularly during the recent COVID-19 pandemic. Thus, healthcare practitioners and health technology policy-makers should consider a long-term perspective of these technologies and innovations and how they could impact organizations, society, the environment, and the economy.

Finally, patient confidentiality and ethical perspectives on the use of eHealth were almost nonexistent in the literature, although they are vital in providing equal and secure healthcare delivery [93]. Hence, further research on eHealth in Southeast Asia should explore technology adoption, data privacy, data security, and ethical issues in eHealth. To summarize, this bibliometric review provides a valuable contribution to discussing and analyzing the literature and sets the direction for future research in eHealth in the Southeast Asia region.

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