Systematic Literature Review of Major Themes in New Zealand Health Informatics Research

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Abstract

Over the last decade, health informatics has risen to prominence in New Zealand's health management landscape. The importance of better health-related data management and generating insights from the system is growing in popularity. This research aims to determine the major themes of health informatics in New Zealand. The research uses a systematic literature review to identify the major themes. With the systematic literature review, the research found that health informatics is focused in the following themes: conceptualisation of health informatics, big data analytics (BDA) in health informatics, types of health information systems, history of health informatics, and teaching nursing informatics. The themes are interrelated to enhance the better provision of services and establish answers to challenges that threaten existing services. Based on the research findings, the discussion is presented to guide health informatics researchers, and will help them to identify the research themes that can be investigated further. The interrelationship between these themes is based on the idea that they concentrate on devices, methods, and interventions needed to promote the attainment of big data analytics in health informatics and its use in medical and health decision-making. This study might also guide the development of health informatics policies in the nation. Based on the faster development of health informatics, the interaction of these themes offers opportunities for informatics specialists to enhance the practices and services in the medical field.

Keywords: Health Informatics, Medical Informatics, Healthcare Information Systems, Systematic Literature Review

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Attestation of Authorship

I hereby declare that this submission is my own work and that to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgments), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signature：

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Chapter 1: Introduction

1.1 Overview of Health Informatics

Health informatics is considered a sub-discipline of information systems. It is at the intersection of other disciplines such as social sciences, information technology studies, medical care, psychological and behavioral studies, and health practices. In health informatics, these multi-disciplinary fields are entwined to meet practitioners' needs in the medical field. Health informatics focuses on the data acquisition, recovery, processing, analysis, demonstration, and use of medical and health decision-making information, and various other kinds of communication technologies primarily powering health informatics in New Zealand (Gotz et al., 2019). According to Gotz et al. (2019), these technologies are internet-enabled technologies, information technologies, displayed on hand-held or mobile devices, telecommunication infrastructures, and systems.

The main objective of health informatics solutions is to offer innovative and suitable application technologies for enhancing healthcare information delivery. ‘Health informatics’ is an umbrella concept that encompasses terms such as telehealth, mobile health, clinical decision support systems (CDSS), and electronic health (e-health) (Karmaker, 2020). According to Gupte, 2019, ‘health informatics’ is an umbrella concept that includes communications, networking, and computing. With the advancement in big data analytics, the scope of health informatics has further extended to areas such as social media data exchange, file sharing, video conferencing, and blogging. The importance of health informatics has also led the researchers to study the field and identify the themes that dominate this field. For example, Abdullah et al. (2015) carried out a systematic literature review to examine the application of health informatics in four traditional medicine systems, such as Traditional Malay Medicine, Chinese Medicine, traditional Arabic and Islamic Medicine, and Ayurveda.

Similarly, Gotz et al. (2019) did a literature review to explore the medical informatics research undertaken by American academics. The findings of Gotz et al. (2019) indicated opportunities for

both innovation and expanding evaluation practices for visual analytics technologies across health contexts. The current study adds knowledge to these existing studies and is different from them as its emphasis is on understanding the themes of health informatics in New Zealand.

1.2 Benefits of Health Informatics

Health informatics can help predict diseases, (I would say"…predict disease infection rates" or something like that here) novel drug discoveries, robotic surgeries, medical image analysis, reduction in human labour, and providing fast service delivery to patients. Similarly, bots, clinical decision support systems, smart houses, and robotic assistance are some applications of health informatics.

Health informatics can also help resolve over-diagnosis/over-treatment issues. For instance, one-third of cancer diagnoses done to screen cancer in patients may show over-diagnosis. Cases of over-prescription, over-testing and wasted resources are also some of the challenges (St. George & Harp, 2011). The introduction of artificial intelligence in healthcare has provided better insights into the accurate and efficient prescription of medicines. New Zealand has an array of quality health datasets, including data on health service delivery. Health informatics can be used to predict illness prevalence and patterns.

Health informatics can aid in interpreting medical results, like mammography scans, which are used to detect breast cancer in women. The technology can be employed in other screening and reading of previous images to detect differences by comparing the initial clinical reports. Genome mapping projects also produce a wide range of data that is used to diagnose and prevent disease.

1.3 Research Objective

Globally, knowledge of health informatics competencies and the importance of local content are acknowledged as crucial themes in health informatics. Understanding the local health informatics content is critical since this knowledge is directly required to build region-specific training and

education programmes. According to McKenna's survey-based study (McKenna 2010), electronic interchange of medical test results can considerably increase the effectiveness of the New Zealand health sector. Similarly, health informatics skills will be critical in the New Zealand health industry in the future (Siricharoen 2010).

Importantly, no research has been conducted that discusses major themes of health informatics in New Zealand. The current study will help local practitioners and researchers, and also benefit the international health research community**.** This study aims to understand the major themes in creating health informatics solutions in New Zealand for both practitioners and organisations. This study addresses the research question: *What are the major themes in New Zealand health informatics research?*

1.4 Dissertation Structure

This dissertation is arranged as follows. Chapter One outlines an introduction to the study, offers the research question, and presents the overview of the dissertation. Chapter Two is about the research method and thematic analysis, while Chapter Three provides the major themes of systematic literature review. Chapter Four provides the discussion concerning the relationship between major themes and outlines a theory that explains the New Zealand health informatics landscape. The last chapter presents the conclusion.

Chapter 2: Research Method

Conducting a review of the health informatics literature is an essential part of this study. According to Templier & Paré (2015), the literature review approaches are: narrative review, theoretical review, critical review, descriptive review, comprehensive review, systematic review, and meta-analysis. Unlike traditional reviews, the purpose of the systematic literature review is to provide as complete a list as possible of all the published and unpublished studies relating to a particular area of study. While traditional reviews attempt to summarise the results of many studies, systematic reviews use explicit and rigorous criteria to identify, critically evaluate and synthesise all the literature on a particular topic. It will minimise the impact of errors and help end confusion when interpreting information; combining findings from different studies can also highlight new findings.

The systematic literature review (SLR) assists in identifying any gap on specific issues in this field. It contrasts traditional narrative studies using transparent, scientific, and replicable producers (Taylor, 2012). It assists in gathering all related documents and publications that are applicable to the researchers' pre-defined inclusion criteria to address the specific research question (Taylor, 2012). According to Okoli and Schabram (2010), when the process is done well the research can offer reliable results and conclusions to help the research community, medical practitioners, and decision-makers. It can be helpful to produce more accurate data on the topic under the study of health informatics. Systematic reviews can also reveal areas of the knowledge gap. This knowledge can then be used to guide future research. So consequently, the literature review is best suited for my research study (Okoli & Schabram, 2010). The primary steps in conducting the SLR, as mentioned by Okoli & Schabram (2010), are as follows:

1. Formulating the research problem
2. Searching for literature
3. Defining exclusion and inclusion criteria
4. Evaluation of the quality of chosen studies
5. Extracting data

6. Thematic analysis.

SLRs in health informatics aim to organise studies and help to simplify their process, and guarantee them success in their activities (Okoli & Schabram, 2010). Therefore, I used the SLR technique to derive more in-depth insight into the current health informatics research through three planning stages: formulating the research problem, searching for literature, and assessing quality (Taylor, 2012).

2.1 Formulating Research Problem

Health informatics research is a multi-disciplinary field that involves various types of information processing to meet practitioners' needs in the medical sector. Meeting the information requirements of the practitioners needs research that focuses on a diversity of academic and practitioner resources. Also, this research can help in the identification of required infrastructure as well as information technologies.

Generally, health informatics is a multi-disciplinary field with broader coverage of numerous sub-fields that need research to understand better. Research conducted in New Zealand has attempted to comprehend the major themes of health informatics in New Zealand. However, most of this research is focused on a single issue. McKenna (2010), for example, found that the electronic exchange of medical test results can significantly improve the whole efficiency in healthcare in New Zealand in a survey-based study. Similarly, according to another survey-based research by Siricharoen (2015), health infographics expertise will be a critical demand in healthcare New Zealand in the future.

There have been no previous studies that have provided a comprehensive overview of the health informatics landscape of New Zealand. As a result of this research gap, there is a lack of information on the primary themes of the New Zealand informatics landscape. This study focuses on the major themes and outlines a theory that explains the health informatics of New Zealand.

The study's findings will provide information about the local content and immediately contribute to health informatics training programmes.

Globally, health informatics competencies and the local content's importance are identified as major themes in health informatics. Understanding the local health informatics content is essential as such knowledge is needed to design the region-specific training and education programmes (Hübner, et al., 2018). As a result of this study, researchers will have a landscape for establishing a foundation for their learning in health informatics. Although research in the health information domain is not new, the findings of this study suggest the need to investigate and improve some emerging sub-fields of health informatics. By proposing new research fields on advanced health systems, their users and user settings, it will provide an understanding that will encourage practitioners and other researchers in the health informatics field.

The research on the primary themes is also helpful in building topic guides and survey questionnaires and designing training programmes (McKenna, 2010). As a result, examining the main themes of the issues in the New Zealand health informatics landscape is crucial for the health sector in the country. The specific research question that the study addresses is: What are the major themes in New Zealand's health informatics research?

2.2 Searching for the literature

The search was conducted across Science Direct, as it is the leading source of medical, scientific, and technical research worldwide. Moreover, Health Informatics New Zealand (HiNZ) is a primary source of information for this study. The Health Care and Informatics Review Online Journal (HCIRO) has an archive of research papers focusing on health information technology issues. There are many papers explicitly published on health informatics research conducted in New Zealand and these relevant papers are identified between 1st January, 2015, and 31st December, 2020. The author searched using two terms, "health informatics" and "healthcare analytics," to find studies which have the search term in the abstract, body, and keyword of the

paper. Search names were keyed into the Science Direct database using the terms "healthcare" or "health informatics" and "New Zealand" in a general perspective to obtain the relevant articles for literature review. At first, I evaluated the titles of each study and used pre-defined exclusion criteria, namely:

- Not in English
- Mini-reviews
- Non-scientific articles
- Unpublished thesis papers
- Newspaper articles
- News and book chapters
- Editorial
- Those published in the abstract.

The inclusion criteria were:

- Articles from reputable sources
- Relevant to the research topic
- Country-specific (New Zealand)
- Published between 2015-2020

  The reason to choose five years is to get a manageable amount of articles that can be reviewed within six months and ensure that the chosen studies have up-to-date information for the correct conclusion.

Hence, the author obtained a set of possible appropriate sample articles. The articles' full text was then acquired and critically assessed. After the selection of those five years, an initial listing of 180 articles was identified. After excluding duplicates, and the studies that were not fulfilling the research foci, 130 articles were found. This was further filtered for studies that were NZ-specific. This gave me a list of 80 studies. Of these 80 studies, 33 studies were removed as these were not relevant. This led to selecting 43 documents for review, as shown in the Figure below.

2.3 Defining exclusion and inclusion criteria

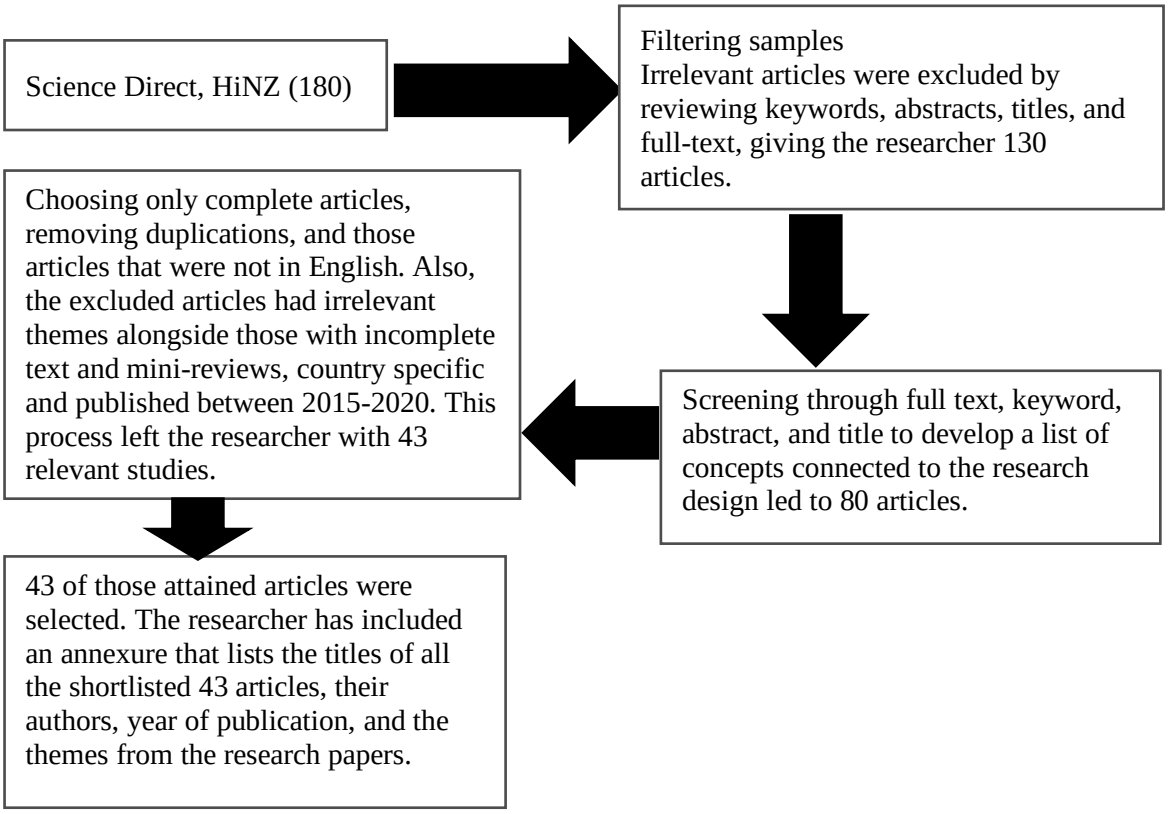

Figure 1: Filtering criteria of the attained articles

2.4 Evaluation of the quality of chosen studies

Much consideration was put into articles published by Science Direct and HiNZ to guarantee that only eligible publications were chosen from 180 articles. As part of this procedure, the researcher eliminated low-quality non-scientific articles, newspaper articles, unpublished thesis papers, articles published in abstract, interpretative articles, and editorial notes. Papers related to the research question were included to broaden the thinking, which allowed an easier conclusion to be made. Figure 1 outlines all the steps in this process.

2.5 Extracting the data

At this stage, the author has an exhaustive list of articles for the final review. This step is significant as this is where relevant data has been extracted and is the foundation of the analysis.

Any slight mistake will make for the wrong interpretation of research in the analysis stage and seriously affect the conclusion (Templier & Paré, 2015). Figure 2 below shows the screenshot of included articles which were included as Annexure B.

Yang, Huang, Liu, Li, & Hu	2017	Big data and cloud computing present both opportunities and obstacles for innovation.	Provides abundant data and chances that improve and enable research and decision support submissions for modern-day applications, such as medicine, science, business, and engineering.

Figure 2: Screenshot of the summary of the included article

The table contains the author's name, year of publication, the title of the article, and the findings, which became the foundation of the research. The analysis of included articles concludes the list of themes.

2.6 Thematic Analysis

In qualitative research, thematic analysis is a common form of data analysis. Braun and Clarke produced an article in 2006, introduced to new researchers through the steps of using thematic analysis. Thematic analysis, according to Braun and Clarke (2006), is a foundational approach of analysis that needs to be defined and documented in order to establish its place in qualitative research.

The coding procedure in six phases develops established, relevant patterns in the thematic analysis (Braun & Clarke, 2006). Thematic analysis is straightforward to use, making it ideal for beginning researchers who are inexperienced with more difficult qualitative analysis methods, allowing for the researcher's choice of theoretical framework to be flexible. Other types of analysis are related to specific theories, whereas thematic analysis can be applied to any theory the researcher chooses. So, Braun and Clarke's (2006) Six Phases of Thematic Analysis were used in this research, and the six phases are as follows:

i. Familiarity with the data
ii. Generation of initial codes
iii. Search for the themes
iv. Review of the themes

v. Define themes

vi. Write-up

With thematic analysis, the included articles were reviewed. The following Figure 3 shows the screenshot of the thematic analysis table, which I have included as Annexure A.

Big Data	This review found that many studies were published about big data in New Zealand. For example, data analytics frameworks purposed for prediction analysis are expected in assessing an extensive health dataset. Hu et al. (2017) defined the comprehensive data analytics framework based on cloud computing integrated into smart devices and GIS for taking and visualizing big data. A predictive model for health shocks supported the study using various households' inaccessible rural areas within New Zealand. A description of the extensive data-enabled system purposed at creating a health status prediction method that adopted big data processing concentrated on applying the machine learning model. Chiroma et al. (2016) presented data analytics using data mining methods to execute a faster mining tool to detect New Zealand diseases. These researchers used a classification method based on decision trees and cross-validation to locate records before seeking the doctors' advice. Besides, Badfar et al. (2019) outlined the effects of data processing and analysing big healthcare data produced in cloud computing for decision-making. Analysis of large-scale data was gathered automatically from a variety of healthcare devices and applications. Consequently, to attain better performance and solve scalability issues, a distributed big data system is significant for addressing the data diversities of a cloud setting.	Telecare and telemedicine topics in health informatics are perceived as essential topics, revealing promises for future knowledge development in the field.	Yang, C., Huang, Q., Li, Z., Liu, K., & Hu, F. (2017). Big Data and cloud computing: innovation opportunities and challenges. *International Journal of Digital Earth*, *10*(1), 13-53.

Figure 3: Screenshot of thematic analysis table

This systematic approach helped the researcher to relate the data on the themes and the theory explaining health informatics in New Zealand to the research question. The researcher was able to finalise the major themes that were identified from this information and subsequently answer the research question. Then the relationship between the major themes was found which was concluded in the final report.

Chapter 3: Literature Review

In this chapter, the author presents the major themes of the systematic literature review. The analysis of (forty-three research papers) suggests that the main themes discussed are the history of health informatics in New Zealand, conceptualisation of health informatics, types of health informatics, big data analytics, and the evolution of the teaching of nursing informatics. Each theme is described below.

Health informatics is a discipline that relates healthcare medical practice with information technology and business. Health informatics focuses on health data management and analysis to facilitate the organisation's problem-solving and decision-making. The review of the selected research papers indicates the health informatics research themes in New Zealand. For example, health informatics research in New Zealand focuses on addressing the problems caused by diabetes and obesity (Gauld et al., 2011). One stream of health informatics research has focused on health professionals' roles (such as nurses), and how health informatics can improve their working conditions by making them more informed (Honey & Westbrooke, 2012).

Healthcare informatics is a field that bridges the gap between medical practice and the use of technology and the health industry. Health informatics is concerned with the management and analysis of health data to help organisations solve problems and make better decisions. According to Alegria et al. (2018), health informatics systems are built for the principal purpose of acquiring, using, and storing patients' health information for the sake of excellent healthcare delivery by medical professionals. The incorporation of technology is the easiest and safest way to do this because technology has multiple functionalities that make this work with greater accessiblity, and is much more convenient for both patients, and medical professionals. Some studies have discussed incorporating health informatics in the educational curriculum of undergraduate health

professionals (Honey, Collins & Britnell, 2020; Honey et al., 2017). The review indicates patterns in the themes of health informatics research in New Zealand. This research explores the informatics research landscape in greater detail through a systematic literature review.

3.1 History of Health Informatics in New Zealand

A critical theme in the literature was related to the history of health informatics in New Zealand. This health informatics history can be divided into three eras: initial, medieval, and modern stages of health informatics development in New Zealand. The figure below presents the significant events that happened in each of these stages.

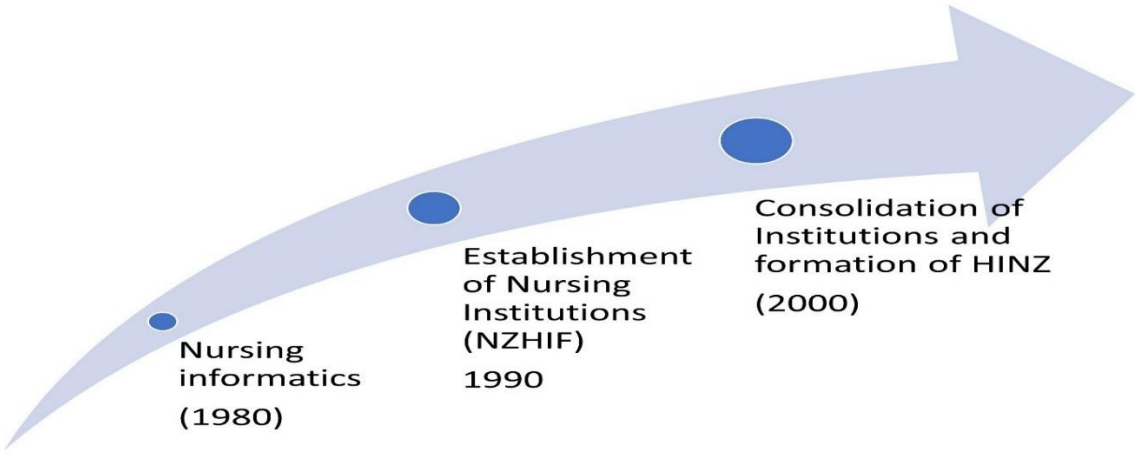

Figure 4: The major events that happened in the development stages of health informatics in New Zealand.

Each of these sections is discussed in the sections below.

3.1.1 The first development stage of New Zealand health informatics

It seems that the history of health informatics in New Zealand is rooted in nursing informatics initiatives that were started in the late ’80s. In 1986, Kathryn Hannah, a Canadian nurse, visited New Zealand and met senior nurses from education and clinical settings. Their meeting focused on the effect of computers on the work of clinicians (Day et al., 2020). From the Department of Nursing at Manukau Polytechnic, Jan Hausman attended this meeting (Day et al., 2020). There was an increasing awareness of the necessity for New Zealand to become more ready for nursing informatics. Later, Hausman was funded by the New Zealand government to establish a national

nursing informatics curriculum completed and published in 1989 (Day et al., 2020). In this curriculum, the nursing informatics competencies, attitudes, skills, and knowledge were identified. Although each school was provided with the curriculum document and a group of teaching resources and packages, the introduction of nursing informatics was not equivalent, with some educational institutions emerging as leaders since they had more experienced educators.

The analysis of the literature indicates that health informatics in New Zealand has its origin in nursing informatics. The early beginnings of nursing informatics are usually traced back to the 1980s, though the initial national organisation was not created until 1991. Nursing informatics developed through a period of intense transformation and reliance on technology in the medical field.

3.1.2 The second development stage of New Zealand health informatics

This second stage started in the early 1990s. This stage saw the establishment and development of Nursing Informatics New Zealand (NINZ) and the NZ Health Informatics Foundation (NZHIF) to create the present national integrated society called HINZ (Honey et al., 2017). Nursing informatics had already developed well internationally, with the International Medical Informatics Association (IMIA) and Group 8 (WG8) already formed. This Working Group changed in 1994 to Medical Informatics Association – Nursing Informatics (IMIA–NI), a body considered to be a Special Interest Group for Nursing Informatics (Honey et al., 2017). The triennial Nursing Informatics conferences and the fourth conference in 1982 and 1991 in Melbourne made Australia a vital destination for stimulating New Zealand nurses' interest, leading to the development of NINZ.

Hausman disseminated a discussion document in 1990, suggesting that New Zealand was to have a conference for the forthcoming 1991 IMIA-NI conference in Melbourne. A fruitful conference themed "Nursing informatics in New Zealand: An impetus for learning" was realised, with more than a hundred nurses attending (Baumle et al., 2018). Nurses who had an interest in nursing

informatics were identified in this conference, after which all participants were asked for a meeting to create the National Nursing Informatics Group (Nagle et al., 2017). The new group aimed to ensure the nationwide growth of knowledge and information systems in all nursing practice fields. Therefore, the term Nursing Informatics New Zealand was embraced. Goals, aims, and terms of reference were made, and the plan was to attain them through peer support, newsletters, and workshops (Asiri, 2016). Marilyn Appleton, Robyn Carr, and Jan Hausman led the early years of NINZ, while Ann Browett, Lucy Westbrooke, and Michelle Honey took the chairperson's role over the following years (Honey et al., 2017). NINZ transformed into an integrated society within a few years, developed an online presence, and hosted regular conferences, seminars, and workshops.

In New Zealand, nursing informatics developed due to the determination of a small group. International friends supported its development, such as the then president of IMIA, Marion Ball (Asiri, 2016). Marion Ball advised that in order to develop as an organisation, NINZ and New Zealand should have a representative at IMIA-NI conference in Melbourne. This role was ably undertaken by Robyn Carr, who provided fifteen years of outstanding representation.

In 2000, there was an increased suggestion for New Zealand to host the seventh international congress since NINZ was growing in strength (Asiri, 2016). Afterward, New Zealand won the bid to hold the seventh International Nursing Informatics Conference (NI'2000) in Auckland.

In the late 1990s, people realised the necessity of a combined concentration on health informatics, leading to Health Informatics New Zealand (HINZ) (Honey, Collins, & Britnell, 2020). During this time, New Zealand also passed through several health reforms, which have contributed to the IT Health Board's present structure and a National Health Board (Honey, Collins, & Britnell, 2020). The establishment of these bodies has made clinicians recognise the need to take part strategically to enhance the significance of technology and information in impacting positive health results.

According to Asiri (2016), NINZ was the first health professional informatics group developed in New Zealand. Unfortunately, the initial discussion about HIANZ and NZHIF declined due to differences in their operations. As NINZ grew, it formed associations with numerous international and national bodies and organisations. The group formed relationships with the health information systems vendors, the Ministry of Health, and other professional bodies. Also, NINZ members were engaged in forming NZHIF, which had a more comprehensive health focus and integrated vendor community. This readiness to work with others guaranteed the feasibility of nursing informatics in New Zealand.

3.1.3 The third development stage of New Zealand health informatics

The establishment of HINZ was planned for a long time but could not be materialised until the IMIA-NI 2000 conference when NINZ finalised the responsibility and accountability of hosting the NI'2000 conference. The combination of various groups, such as NINZ and NZHIF, led to the establishment of Health Informatics New Zealand (HINZ), chaired by Ann Browett (Asiri, 2016). HINZ formed working groups aligned to the IMIA-NI and IMIA working groups, and the initial one was the Nursing Informatics group (Asiri, 2016). It was developed to get regular communication regarding health and specifically health informatics-related events and activities. HINZ hosts the Health Informatics Conference annually, and most of the main speakers are nursing informatics leaders.

Thus, it seems that the history of health informatics in New Zealand has passed through the stages in which there was a catalyst stage in which the Canadian nurse and her arrival to New Zealand acted as a stimulus for starting the nursing informatics initiatives. After the catalyst, there was a stage that saw the establishment of institutions related to health informatics, and in the final stage, these institutions became firmly established.

3.2 Conceptualisation of Health Informatics

Health informatics is often used interchangeably with terms, such as biomedical informatics and medical informatics. Modave et al. (2018) described this field as "information engineering for medical care as it helps transform information, making it important in offering medical services. It is referred to as engineering as the information accessed is changed for easier use by the interested individuals" [63]. Hoyt and Hersh (2018) defined healthcare informatics as "a multi-disciplinary field that utilizes health information technologies to promote healthcare services through efficiency and quality". Health informatics amalgamates communication and information systems, formal medical terminologies, and clinical guidelines (Hoyt and Harsh, 2018).

Health informatics is an integrated discipline that involves many interoperable technologies and data. Appropriate data is a fundamental requirement of efficient health informatics. The domains of health informatics concentrate on more comprehensive health systems data and relate to patient data in the health informatics systems. Higher quality and richer data sets can be attained through the interoperability of health information systems, using a standard data exchange mechanism and data standardisation. The current research has indicated that they had taken advantage of the possibilities provided by health informatics; medical practitioners must be able to obtain appropriate data and be at ease with its application (Hu et al. 2017)). This situation was the primary motivation for training and education in the information technology part of the New Zealand health system's national investment.

Therefore, health information technology is a solution for the accessibility of high-quality information, potentially involving a variety of technologies (Roentgen et al., 2018). In New Zealand, reliance on health informatics increases as availability, access, and basic knowledge of electronic information systems improve, and become more prevalent. As it encompasses multiple components of health systems, health informatics is becoming increasingly important in improving health outcomes in New Zealand as a result (Wang, Kung, & Byrd, 2018). However,

it is mainly concerned with the procedure of making health-related data accessible and is valuable for evidence-based decision-making.

Health informatics "is the scientific endeavor, which applies statistical modeling, computer technology, and information science methods to make decision support system for promoting both patient care and organizations' performance outcomes" (Zhang & Shahriar, 2018). Also, this concept is the interdisciplinary study of the following features: adoption, development, design, and implementation of IT-based innovations. Typically, these are practiced in the delivery of medical services, planning, and management information science which refers to all the methods that are employed in making certain decisions. It also involves the use of technology in ensuring that answers to given issues are found and used in the right way (Zhang & Shahriar, 2018). The multidisciplinary fields that form part of health informatics are as follows: information sciences, management, social, behavioural, and artificial intelligence. Hersh and Hoyt (2018) emphasised that this multidisciplinary field focuses on the techniques, devices, and resources needed to optimise information retrieval, storage, acquisition, and use in biomedicine and health.

Hoyt and Hersh (2018) suggested that health informatics aims to:

I. Create, execute, and refine clinical decision support systems
II. Characterise, assess, and refine clinical processes
III. Evaluate the knowledge and information needs of patients, communities, and practitioners
IV. Engage in the creation, customisation, procurement, execution, assessment, management, and constant enhancement of clinical information systems.

According to Kumar et al. (2019), health informatics is comprised of the following components:

i. Healthcare service provision systems and technologies
ii. Knowledge management systems for healthcare users
iii. Data acquisition systems and technologies for medical support and healthcare
iv. Decision support systems for medical and healthcare purposes

v. Clinical information systems

vi. Computational intelligence, and data analytics systems and applications, and

vii. Integrated data repository and management systems.

American Health Information Management (2018) has also provided a conceptual framework that suggests health informatics is comprised of financial, clinical, and technological components. The framework taken from American Health Information Management (2018) is presented below.

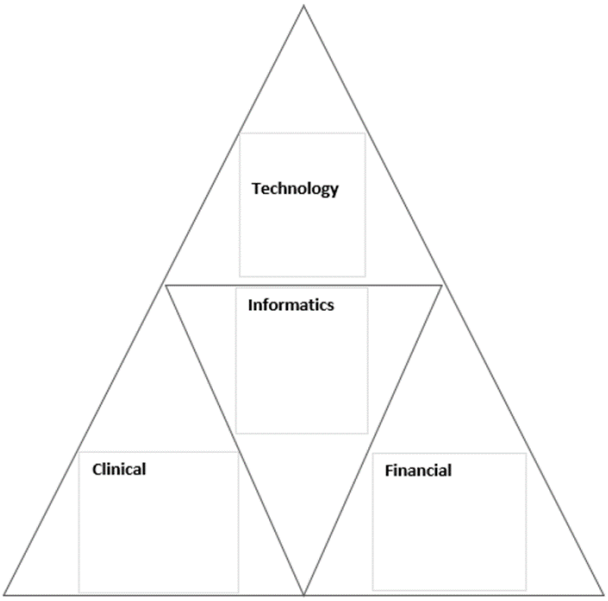

Figure 5: Basic conceptual framework of health informatics as per American Health Information Management (2018)

Based on the above definitions of health informatics, Table 1 below presents the core disciplines and the stakeholders in health informatics.

Table 1: The core disciplines and the stakeholders in health informatics.

Author	Core disciplines in health informatics	Beneficiaries and stakeholders
Modave et al. (2018)	Information Engineering	People seeking medical care
Hoyt and Hersh (2018)	Multidisciplinary, Health Information Technologies	People seeking health care services
Wan and Gurupur (2020)	Information Science, Statistics, Computer Technology	Patients, Organisation
Zhang & Shahriar (2018)	Inter-disciplinary, Information Technology Innovation	Stakeholders in delivery and planning of medical services

Kumar et al. (2019)	Healthcare Service Provision Systems, Knowledge Management Systems, Data Acquisition Systems, Decision Support Systems, Clinical Information Systems, Intelligence Systems, Data Repository, and Management Systems	Healthcare users, people seeking medical support
American Health Information Management (2018)	Financial, Clinical, Technology	Patients, Health Care Organisation, Healthcare Industry

Analysing the terms used to describe health informatics reveals that it is conceptualised as an integrated concept that includes information processing disciplines such as information engineering and information sciences. Also, it includes disciplines such as medicine or clinical studies, computer sciences, technology, finance, and data management. Since it is conceptualised primarily as information engineering or information science, it is crucial to understand the difference between them. Information engineering (IE) refers to the processes undertaken to make the gathered information helpful (Watson, 2018). According to Watson (2018), information engineering (IE) refers to the methodology for creating a unified information system for sharing common data, with a concentration on transaction-processing (TP) requirements and decision support needs.

By contrast, information science refers to the whole process involved in gathering, storing, and using the acquired information (Watson, 2018). Informatics focuses on numerous elements and includes various academic disciplines. Each takes part of this concept as its natural sphere.

An analysis of these definitions suggests that health informatics is a multidisciplinary field that focuses on health information management and its analysis to facilitate organisational decision-making. The primary beneficiaries of health informatics are medical staff, the patients, the community, and the organisation.

3.3 Types of Health Informatics

An analysis of the literature review indicates that authors have also discussed the types of health informatics systems. Health informatics involves a combination of technology and medical knowledge based on these combinations. There are also different health informatics systems. One type of health informatics system is mobile health informatics systems, often called "M-health." Chang and Shen (2018) stated that M-health is perceived as a mobile application or service for offering healthcare support anywhere, anytime, and to anyone. Therefore, using the processing power of mobile phones, Internet technologies, and GPRS, M-health offers stakeholders support services to administer, gather, disseminate, manage, monitor, and control healthcare information and improve quality of care support and health service delivery (Murphy et al., 2020). M-health applications remove temporal and geographical constraints while at the same time ensuring cost savings, coverage, and quality of health services.

According to Hasan et al. (2017), a particular type of mobile health informatics system is the Clinical Decision Support System (CDSS). CDSS directly facilitates clinical decision-making, where individuals' characteristics are compared to a computerised knowledge base to produce patient-specific recommendations. When all these tools are combined, mobile decision support applications are made for reinforcing decision-making in non-clinical and clinical contexts (Aghamohammadi et al., 2019). Based on the presented information, the studies undertaken over the past decade in New Zealand have been viewed in three categories:

i. Mobile-based decision support for improving public healthcare or public use
ii. Mobile-based decision support for outreach health professionals, and
iii. Mobile-based CDSS for medical experts and physicians.

3.4 Big Data Analytics and Health Informatics

An essential theme in the health informatics literature of New Zealand is the role of Big Data Analytics in health informatics research. Big data analysis is the use of advanced data analysis techniques for the analysis of very diverse data sets. These data sets may vary in terms of source

and type. The data collected goes beyond the use of standard relational databases and captures more information than they usually can handle (Hu et al., 2017). Data sources in healthcare are very comprehensive, and they are usually not all stored in the same media. This results in an increased risk of data fragmentation, resulting in decreased quality of care (Chiroma et al., 2016). The importance of these analytics is seen in various sectors when it comes to patient care, and the management of all data related to healthcare.

Authors have explored the role of big data analytics in many areas, namely:

1. Structured and unstructured data sources
2. Types of analytics (descriptive, predictive/prescriptive)
3. Administrative and clinical decision-making
4. Diagnosis and treatment of patients
5. Web and social media analysis
6. Role of text mining
7. Patient demographic and privacy issues.

3.4.1 Use of structured and unstructured data.

Data sources in health informatics are divided into two types: structured and unstructured data. Specifically, unstructured data sources include surgical reports describing the details of a successful surgery. This includes discharge letters that direct patients to professionals. Consequently, daily internal notes serve as the structured data source for health informatics. Also, there are protocols relating to the textual representation of the outcomes of some procedures, such as textual understanding of a Magnetic Resonance Imaging (MRI) scan (Gore vdd al., 2016). (Is this supposed to read (Gore et al., 2016)? Please check) Another unstructured data source are letters, such as an attestation letter confirming some claim; for instance, a medical leave of absence or a formal letter enquiring for medical service and appliances.

One example of the structured data sources in health informatics includes lab results, which include test id, test results in a definite value, or a medical conclusion. Consequently, inpatient

medication prescriptions are generally a set of prescribed medications in terms of the Anatomical Therapeutic Chemical Code. Another structured data source of health informatics is oncological pathology codes that describe abnormal tissue growth achieved after biopsy analysis (Den Bulcke et al., 2016).

3.4.2 Types of Analytics

Descriptive, diagnostic, predictive, and prescriptive analytics are the four kinds of analytics used in health informatics (Den Bulcke et al., 2016). Specifically, descriptive analytics uses data statistically to suggest what happened in the past. This concept assists a business in recognising how it is doing by offering a setting to help stakeholders explain information (Den Bulcke et al., 2016). This can be depicted in the data visualisations, such as dashboards, reports, charts, and graphs. Also, diagnostic analytics extends descriptive data further and offers detailed analysis to answer some questions.

In most cases, diagnostic analysis is called root cause analysis that entails using various processes. Predictive analytics adopts historical data and puts it into a machine-learning model based on key patterns and trends. After that, the model is applied to present data to forecast what will happen next. Finally, there is prescriptive analytics that adopts predictive data to the higher level.

Moreover, BDA use in the New Zealand healthcare system is gradually increasing. Moro, Visconti, and Morea (2019) reinforced this claim by stressing, that amongst the potential sources of big data in this field were multi-spectral and heterogeneous observations, such as diagnostic reports, treatment history, and patient demographics. They further recommended that such data may be unstructured (such as medical imaging, prescriptions, and clinical notes) and structured (such as genomics, phenotype, or genotype data). Executing data in healthcare often needs the production and gathering of high-quality real-time data. Decision-makers in healthcare organisations take action based on important insights gained from big data (Greene et al., 2018). Therefore, New Zealand healthcare organisations use technologies to deal with the varying nature

of big data. In medicine, big data can be utilised to connect diverse sectors and research disease more extensively.

The use of BDA has opened up many healthcare possibilities. In this regard, when using big data, prescriptive, predictive, and descriptive-analytical methodologies can help improve the quality of a variety of healthcare aspects (Mäntymäki et al., 2020). The existing literature proposed BDA's diverse healthcare opportunities, such as medical diagnosis, community healthcare, hospital monitoring, and patient care. In terms of medical diagnosis, data-driven diagnosis in New Zealand has the potential to detect illnesses early and reduce treatment complications (Greene et al., 2018). Authorities in community healthcare may take preventative measures to protect the public from chronic diseases and contagious disease outbreaks (Verma & Sood, 2018). Based on hospital monitoring, real-time checking of hospitals can assist government authorities in offering the maximum quality of service. Besides, customised patient care aided by BDA can provide rapid relief and minimise readmission rates in medical organisations.

Most studies have revealed that BDA in the New Zealand healthcare system is gathered into five broad themes: hospital dimension, clinical dimension, outpatient care centres, specialised care centres, and mobile care centres. The first one is the clinical dimension, which could benefit healthcare services and patients in New Zealand; this is the electronic personal health record (PHR). According to Fylan et al. (2018), PHR is the online system that gathers clients' medical and healthcare data, utilising health informatics standards to share, organise, and manage them based on their opinions. Some of the identified importance of PHRs is the capability to promote patients' results, improve medication adherence, increase access to care, especially in remote regions, and decrease care costs (Fylan et al., 2018). In most cases, medication adherence in New Zealand is a common challenge in healthcare. It is connected to numerous factors, such as effective self-management, forgetfulness, side effects, and psychological beliefs. McQuaid and Landier (2018) claimed that medication adherence is the degree to which individuals' behaviour

towards their medication consumption corresponds with medical professionals' accepted recommendations.

3.4.3 Administrative and Clinical Decision Making.

Administrative decisions are usually made by government bodies, which frequently forces some members of the public to oppose them. This type of decision is involved in addressing things that affect everyone in a given population. Besides, administrative decisions are where government bodies grant legal decisions that refine governmental regulations (Oswald, 2018). These decisions are juristic actions as they come out as if they were legal packaging of daily experiences. Clinical decision-making, on the other hand, describes the primary function of nurse practitioners. As a result, clinical decision-making is a continual process, including data collecting from various sources, which in the New Zealand health industry implies big data.

3.4.4 Diagnosis and Treatment of Patients.

Diagnosis refers to the process of identifying the characteristic of infection and differentiating from other potential conditions. When medical experts choose diagnosing one infection over another, the diagnostic process determines one as the most probable cause of people's symptoms. Big data provides signs that appear earlier in the course of diseases which are usually undifferentiated and vaguer than those that emerge as the infection progresses, making this situation challenging to make a precise diagnosis. The treatment of patients is just the management and patient care to combat infections. This practice encompasses the preservation of mental and physical wellbeing through services provided by health practitioners.

3.4.5 Web and social media analysis

Within big data analytics sources, web and social media data have gained prominence in the last decade. Web analytics refers to data available on the internet, primarily in the form of web pages. Mainly, the web usage is the respective business website data usage. On the other hand, social media analytics refers to data collection from social media networks (Kumar & Shah, 2018). The

use of web and social media analysis is in the initial stages with the concepts related to how web analytics uses data gathered directly from a specific business website.

3.4.6 Advanced health systems

Various cloud service providers provide functionalities to gather and analyse these types of data. For example, Microsoft's Azure Health Cloud is a secure and private health data storage solution designed specifically for Microsoft. The Azure Health AI platform connects siloed health datasets and provides a platform for implementing Artificial Intelligence analytic tools. Microsoft is also releasing bots to help patients identify clinical trials and grasp medical terms and medications. Microsoft bots contain healthcare intelligence and a built-in symptoms checker that can be modified to serve the organisations' best interests (Goodyear-Smith and Ashton, 2019).

Additionally, Microsoft genomics contributes to the advancement of precision medicine by providing services for computational biology initiatives involving big data. New Zealand South Island Alliance is capturing more data digitally and establishing repositories to provide medical practitioners with a wide range of insights on patients, according to Gabe Rijpma, a Microsoft senior director of health and social services Asia (Goodyear-Smith and Ashton, 2019). The technology is capturing presentations, medications, laboratories, and family issues, among other aspects. The University of Pittsburgh Medical Center (UPMC) is working on a $2 billion project to create three modern hospitals, with an empowered medical degree, which is an artificial intelligence that can listen to the conversation between doctors and patients, thus learning from them to make changes in the health sector (Boyle, Grainger, Hall and Krebs, 2017). New Zealand, just like most global countries, has embraced AI in healthcare services through the Google cloud health API. For security and compliance-focused workplaces, Google provides standard-based APIs that enhance actionable healthcare concepts. Google has brought with its solutions in training deep learning models to diagnose diabetic retinopathy from retinols. Google DeepMind has won the critical assessment of structure prediction against Alphafold, and it was recently incorporated by Google Health. Likewise, Apple focuses on growth in healthcare, leveraging their

existing hardware and software technology to enhance clinician and patient's access to health records, improve work efficiency in hospitals, allow customers to connect remotely, and undertake medical research (Boyle, Grainger, Hall and Krebs, 2017).

New Zealand has also seen many small commercial providers of advanced health technology and service providers. Consultancies aiding public entities in creating and implementing AI solutions are examples of commercial ventures. Some examples of these advanced health technology providers are included below:

- **Nicholas Consultancy** has helped Accident Compensation Corporation (ACC) develop analytical, statistical models and programmed claims processes.
- **Vensa Health** has created a digitalised environment in health centres and is working precision-driven health to research and adopt artificial intelligence to analyse laboratory results.
- **Isogonal** is a small start-up that offers unique AI solutions to New Zealand healthcare customers, such as resource utilisation management.
- **Performance Lab** has developed their Association of Religion Data Archives (ARDA) AI platforms to integrate intelligent analytics and wearable devices, such as health tracking watches to provide personalised training for athletic performance and disease prevention and management.
- **Volpara Health Technologies** has created an AI breast cancer screening tool. The company has gone global and has identified a new market in the United States.

3.4.7 Text mining

An important characteristic of big data analytics in the New Zealand health sector is its emphasis on analysing text data. Text mining refers to the process of analysing unstructured text data. This process may utilise natural language processing (NLP), permitting machines to realise human language and automatically process it. This practice automates the process of grouping texts by changing data into information that machines can understand. Big data analytics in New Zealand

give more explicit norms for data sharing, and better clinician participation is required to maximise the potential benefits of big data.

3.4.8 Patient demographics and privacy issues

Patient demographics are critical data for any healthcare institution. Such demographics permit the analysis of the patient's cohort so that patient demographic patterns can be identified. Patient demographics are the initial part of the information collected from patients, and it includes everything from their date of birth to their insurance provider. From the billing point of view, such demographic information helps to identify whom to send any claims, whom to call if there are payment issues, and where to mail the final bill. Data security and patient privacy are concerns in the medical industry (Shen et al., 2020). This situation calls for medical institutions to safeguard against breaches that may put their personal information at risk.

Furthermore, considerable research has looked into the potential use of BDA in the New Zealand healthcare system. For example, treatment techniques, disease diagnosis, patient monitoring, and patient care are likely to benefit from BDA applications. Shen et al. (2020) supported this claim by stating that the Bayesian multitask learning method revolutionises clinical practices by reducing failures and minimising delays in offering preventive interventions. Greene et al. (2018) asserted that healthcare organisations' use of a strategic method in utilising BDA produces business profits. On the other hand, Das et al. (2016) claimed that the trade-off between collecting efficient data-driven healthcare solutions and the privacy issues that come with them has yet to reach an equilibrium.

3.5 Evolution of Teaching Nursing Informatics

The literature analysis also suggests that teaching nursing informatics is another critical theme in New Zealand healthcare informatics research. Teaching health informatics is vital in New Zealand since nurses in this region are the largest regulated health workforce (Day et al., 2020). While analysing the teaching issues in nursing informatics, the sub-themes identified are integration

between nursing informatics and school curriculum, capacity building of educational institutions, and the education and training of health workers. Each of these sub-themes is discussed below.

3.5.1 Integration between nursing informatics and school curriculum

The recognition of the importance of nursing informatics integration within school curricula did not occur despite the early understanding of nursing informatics guidelines and competencies to notify undergraduate nurse education and practice. The Ministry of Education supported Jan Hausman in creating New Zealand guidelines in 1989 for teaching nursing informatics (Nagle et al., 2017). Despite such early initiatives, there was only a minor revolution in the nursing curricula. Williamson and Muckle (2018) emphasised that nursing informatics has not been adequately included in the curriculum across New Zealand nursing schools. Such an idea signals that New Zealand nurses may not be effectively prepared in this field. Evaluation of these studies indicates that the International Medical Informatics Association (IMIA) has incorporated most techniques to offer needed services (Hasman (Can you check the spelling of this author's name – should it be Hausmann?) et al., 2017). Masic and Pandza (2018) supported this idea by stating that the recommendations will fulfill medical experts' educational needs.

Moreover, the study of pharmacy schools in New Zealand revealed little progress in their curricula regarding the teaching and training in health informatics. However, a global approach was recommended in 1986 to offer standard-based, flexible, and Web-based medical informatics education, though this idea has not been well accepted. For instance, a common issue in New Zealand has been the lack of adequately prepared educational institutions to teach health informatics (Lazarus et al., 2020). However, early publications frequently described computers' use by nurses in the 1990s and focused on computer competencies and what should be incorporated in their education. Many countries, including New Zealand, have considered this issue for nurses by realising their specific needs and context. A post-conference meeting of world leaders recently led to the IMIA Nursing Informatics Special Interest Group that considered nursing informatics capabilities (Hisa, Jami, & Pikin, 2019). This meeting documented various

informatics competency recommendations for the nurses who will be educated in the future and covered the relevant skills needed for transformative, innovative, and improved health and health care delivery. As a result, with the expectation that the skills would also assist in preparing nurses for future growth, extensive scope was developed in New Zealand. This was achieved by integrating the use of ICT and information management which were developed for the following aspects: mobile apps, electronic health, patient portals, telemedicine, medical devices, and electronic health records.

3.5.2 Capacity building of educational institutions

The early 1990s saw the creation of various health informatics-related institutions such as the Nursing Informatics New Zealand (NINZ). This institution created and published standards for nursing informatics with the idea that they would direct nursing practice. The formed body was considered a not-for-profit organisation supporting health informatics, focusing on professional developments and events essential for capacity-building educational institutions. HiNZ members consist of government personnel, students, academics, industry managers, ICT experts, health sector managers, and health professionals (including nurses) focused on ensuring educational institutions provide capacity building within the New Zealand healthcare sectors.

3.5.3 Education and training of the health workers

A report published in 2006 identified that for those working as health workers, were to be educated in health informatics (Jensen, 2020). Later on, in 2012, based on the work of IMIA, a group of New Zealand informatics instructors partnered to create the needed competencies under HiNZ (Jensen, 2020). These skills were made available for existing personnel and targeted the stakeholders in the medical field. This situation's primary results were government recognition and financing primer workshops through the guidance of health informatics concepts provided to local medical organisations. There was confidence that such an approach would inform and engage more of the medical workforce in health informatics, which would address the inadequate interdisciplinary team members and health professional champions trained in health informatics

NINZ (Jensen, 2020). Based on past attempts to introduce nursing informatics capabilities in New Zealand, there are opportunities to study and improve earlier efforts. Nicholas (2017) stressed the need to develop networks between the tertiary education providers within nursing schools, hence, crossing observed divisions between institutes of technology, polytechnics, and universities. A demonstration of connections within nursing communities, primarily through key nursing regulatory bodies, policy stakeholders, and nurse lecturers, may be needed to show acceptance of these guidelines to have an impact on policy.

According to Nicholas (2017), there is a requisite to influence the Nursing Council of New Zealand (NCNZ) to address nursing informatics integration within the undergraduate nursing curriculum. The execution of these guidelines would affect all nursing schools in New Zealand by guaranteeing that the current and future registered nurses are often prepared for operating in a technological age. Such practice will potentially have flow-on effects for patient care, improve efficiency and safety within the health care system, and enhance the quality of care for recipients. Also, there would be an appreciation of the nurses' roles in health promotion and their offering of effective services for those sick or dying. Technology is utilised in all domains of healthcare. It guarantees that the New Zealand workforce is sufficiently prepared for its use in the medical field to help all care recipients (Masic & Pandza, 2018). Above all, recognising technology adoption in healthcare is likely to prepare medical experts to be effective and competent. The developed guidelines form a link between the theory of nursing informatics, clinical practice, and the education of nursing staff.

Chapter 4: Discussion

The informatics health themes include the following: the conceptualisation of health informatics, big data analytics in health informatics and different types of health information systems, the history of health informatics, and teaching nursing informatics to have a relationship between them. This chapter focuses on the relationship between BDA and teaching health informatics. The discussion concerning the relationship between major themes outlines a theory that explains the

New Zealand health informatics landscape. This discussion can help in guiding health-related educational interventions.

The relationship between two themes, namely big data analytics and teaching health informatics, is evident. For example, big data analytics presents opportunities for analytically informed decision-making, but it also poses threats to data privacy. Therefore, the students of health informatics must be made aware of various types of privacy breaches. These breaches are well documented in research studies (Kang, Lee, Chun & Song, 2007) and are presented below:

1. Collection without consent
2. Inappropriate monitoring of user data
3. Inappropriate analysis of privacy data
4. Inappropriate distribution of private information
5. Inappropriate use for advertisements/sales
6. Failure to dispose of privacy information.

Similarly, the health informatics students will need to be taught the various BDA-related concepts on the following: data storage, data privacy, data security, data types, data infrastructure, obtaining data insights, and data governance (Marr, 2017). The table below presents these concepts and examples of the contents. This framework can be used for capacity building, training, and education of the health informatics students in New Zealand.

Table 2: Represents the BDA analytics teaching concepts and examples of the contents

Big Data Analytics Teaching Concepts	**Examples**
Data Storage	• Relational Databases • Non-Relational Databases
Data Privacy	• Privacy Life Cycle • Types of Privacy Violations
Data Security	• Data Encryption • Data at Rest

	• Data in Motion
Data Types	• Structured Data • Unstructured Data
Data Infrastructure	• Cloud Computing • Distributed Computing
Data Insights	• Types of Analytics • Machine Learning • Data Visualisation
Data Governance	• Data Accountability • Data Quality • Data Definitions

The two themes, big data analytics, and teaching health informatics, are also linked together to represent the recent development of medicine in New Zealand brought by rapid Health Information Technology (HIT) growth. The extensive adoption of HIT has contributed to new, practical and research problems to health informatics. Preparing the future and the current health-care service providers to excel in understanding the data analytics and to use their skillset to endorse it further, will help in the fast, precise healthcare informatics system in the country and throughout the world (Ding et al., 2017).

The types of health information systems and the history of health informatics are interrelated themes. Understanding the history helps to gain more insight into the context within which health informatics and its institutions are developed in New Zealand. The Electronic Health Record (EHR) is an excellent example of poor user interaction and system usability, cost-related issues, and limited integration with healthcare workflows (Marr, 2017).

Another relationship between BDA and teaching health informatics themes is drawn from the models of informatics researchers to create a new condition of the HIT systems to study the overall

range of health care. Based on the faster development of HIT, the interaction of these themes offers opportunities for informatics specialists to enhance the practices and services in the medical field.

Based on this discussion, the relationship between BDA and teaching nursing informatics can be better understood using the methodology of evidence appraisal (Huggan et al., 2017). Evidence appraisal is commonly driven by a particular rationale frequently connected to a task, professional or institutional requirement. It also is relevant to staff motivation to pursue lifelong learning or in guaranteeing scientific rigour. The appraisal can be conducted at the protocol phase, both near the publication time or long after publication, when more contextual information is present, such as identifying new adverse impacts or new standards of care. In addition, the appraisal is impacted by format, venue, tools used, and appraiser characteristics. From the evidence appraisal, it is clear that all New Zealand Health Informatics themes can be combined to develop evidence appraisal. Such is achieved by incorporating emergent themes linked to evidence-appraisal resources and processes from the theme groupings and domain knowledge in informatics. This process is conducted through interactive, consensus-driven dialogue by the authors. Once organised, the appraisal has several characteristics. One of the features is the stage of the lifecycle of the evidence.

The resulting data can be obtained as a part of the publication or documentation when evidence is appraised. Such data can adhere to data standards, and specific tools or platforms can facilitate its acquirement. The data can then be mapped to an ontology, curated, indexed, and managed in other approaches to enhance data use. Such processes assist in contextualising and characterising the data, significantly making it information that can be integrated, validated, and visualised, permitting the final appraisal knowledge acceptance as part of the use cases. They may then allow the practice and policy decision-making, identification of research priorities, determining possible research questions, methods development, scientific integrity assurance, and evidence synthesis.

4.1 Educational Programmes

Furthermore, these themes can help improve the design of interventions in health informatics in New Zealand. Additionally, these themes can contribute to developing educational programmes to enhance the medical sector in this country. One of the observations that these themes have revealed is that the relationship in health informatics can contribute to the faster growth of technology. Therefore, to effectively maximise the information technology in the quality of health care and medical results, educational arrangement (Is the word “arrangement” correct here? It sounds like “management” was what was intended perhaps! Please check) will enhance nurses at diverse levels for executing information technology tools in all aspects of their occupation.

4.2 The Development of Internet and Network

Apart from educational programmes, different types of health information systems and the history of health informatics themes can improve the design of interventions in health informatics in New Zealand. The internet and network services from various health information systems will foster innovative customer care, thus promoting patient care. The healthcare providers can use past knowledge and the history of health informatics and their improvements to execute the technological tools in the health sector. Currently, there are some informatics-related challenges facing the medical field in New Zealand. These themes imply that there will be an assessment of innovative customer health informatics interventions, which will confirm that the nurses and patients are contented with the use of communication and electronic devices, and home care. Medical experts can have standard networks for nursing organisations and create a platform to discuss nursing issues through online summits. Providing patient care from a distance using telemedicine will be enhanced by using these themes, which act as the nursing practice possibilities in the new decade. Effective remote diagnostic hardware and software will help aid e-health services. Beneficial services in New Zealand are likely to be provided by telenurses since they will be satisfied with their responsibilities. (This last sentence doesn’t sound right – you don’t explain why telenurses are satisfied with their responsibilities. Needs more explanation) The health experts will be offering remote care using unique knowledge and skills, which will

reduce the national demand and shortages of nurses in New Zealand. The designed educational programmes that will be supported through these themes will be capable of working as telenurses. These themes, types of health information systems, and the history of health informatics in New Zealand Health informatics research, will help design outreach programmes and online library resources that would be important in generating positive results for medical practitioners. Such information and communication technology advancement will offer the potential of enhancing health and wellbeing through e-education, regardless of place and time. Patient online education systems may boost consumer satisfaction and have an impact on their self-care behaviour. People in New Zealand will be made aware of infection management and it may improve collaboration between the patient and the professional team of medical practitioners. This practice will have an impact on the prevention of severe diseases and the lifestyle of New Zealanders. It will empower the health care team by promoting and improving their understanding. During a crisis, web-based computer simulation educational programmes will reduce medical faults in emergency departments.

(Close the gap between Chapter 4 and 5)

Chapter 5: Conclusion

The researcher conducted a systematic literature review to identify the major themes in New Zealand health informatics in this study. The researcher undertook thematic analysis to answer the research question, *What are the major themes in New Zealand Health Informatics Research*? The results of thematic analysis yielded the major themes that formed the basis of the theoretical framework discussed in Chapter 4.

This chapter presents the critical conclusions drawn from the study, its limitations, its contributions, and future research that can be based on this study.

Wilson, Jayamaha, and Frater (2018) outlined that in New Zealand, healthcare professionals face pressure from health leaders to improve their effectiveness and efficiency. According to Goodyear-Smith and Ashton (2019), to help medical experts attain such efficiency, much more money needs to be invested in creating health information systems. There is a need for medical experts to improve their knowledge level regarding IT-enabled solutions since a lack of adequate understanding of health informatics principles impedes these initiatives' full benefits (Hackl et al., 2017).

To begin, health informatics must have an operational definition that thoroughly explains the interdisciplinary study of the development, design, implementation, and use of IT-based innovations in delivering, planning, and managing medical services (Zhao et al., 2018). Based on this definition, people can deduce that it is a concept of the intersection of many aspects. The study identifies the themes and sub-themes of the health informatics landscape in New Zealand. Of all the themes discussed, the theme of Big Data Analytics needs careful attention. The BDA themes are comprised of various concepts that are presented in Chapter 4. Understanding the concepts can directly contribute to the knowledge and skills of health informatics students. For example, understanding the different forms of data (structured and non-structured) can help the students extract data from social media and text documents. Various health insurance providers

can also use text analysis to extract textual data from the different online and hard copy forms the customers fill. What should the content of the health informatics and big data analytics study curriculum be, is an important question that arises. An essential contribution of this dissertation is that it provides a framework for incorporating big data analytics teaching in the New Zealand Health Informatics Curriculum in Chapter 4. Past studies have suggested a need for the integration of health informatics concepts in the teaching curriculum (Williamson and Muckle, 2018). This study addresses this gap in incorporating the big data analytics concepts in the teaching curriculum. Thus, the New Zealand government is currently focused on it as these concepts and their associated technologies aid information-driven decisions in the medical field.

The various themes on health informatics have addressed the ways individuals in New Zealand can adapt healthy living medicine to alleviate health threats. In this regard, healthy living medicine seeker citizens use mobile technologies more frequently, enabling personal healthcare control and partnering with healthcare agents or practitioners to have effective healthy living practices. Significantly, such technologies are beneficial with medication and surgery with potential risks of adverse impacts if there are dangers from complicated infections and poor health habits. The telehealth system was established, and its usability was assessed for use in New Zealand.

Health informatics helps design outreach programmes and online library resources, thus generating positive results for medical practitioners. Scaling up or incorporating health informatics first needs stakeholders to consider their urgency to recognise what health information technology can offer them (Hu et al., 2017). Afterward, they need to commit to monitoring the process from selection to structure and execution. As a result, national stakeholders must be ready to partner and coordinate those systems to maximise the benefits in New Zealand. Part of the planning and decision-making process must be based on using a competent workforce capable of installing, maintaining and operating the systems, and managing data. The moment there is the successful execution of the extended health informatics concept, practitioners will realise that

there are positive changes in their daily practices at all levels (Elers, 2018). The possible collaborations are vital if the health workforce at all New Zealand health system levels is involved. An exhaustive understanding of health informatics among New Zealand health workers will contribute to effectual output and outcome benefits (Litton, Guidet, & de Lange, 2020). Education programmes that produce a professional health workforce to make and maintain health information products must be considered throughout the adaptation, adoption, and implementation process.

To address the effectiveness and efficiency ("Efficiency" or "efficacy?" Please check) of problems, the stakeholders have progressively looked to health information technology regarding public health contexts. Such demand has revealed how health informatics relates to the five themes with the types of health information systems in New Zealand.

Health informatics requires the nurses in different places to guarantee the significance of information and technology in promoting New Zealanders' health results. Such perception shows that informatics is no longer viewed as a separate area; instead, it is emerging as a universal aspect of health care (Wang, Kung, & Byrd, 2018). The existing literature has shown that information and communication technologies are vital enablers for the strategic direction, which is being set in the healthcare of New Zealand. Nurses require a tactic to empower them to best use the information and technology to enhance healthcare. Like other countries, health and informatics in New Zealand are linked to the rest of the world struggling with the economic downturn. As seen from the outlined themes, health informatics can reduce costs, errors, and duplication while enhancing communication between practitioners, integration of safety and services (Richards et al., 2019). The main challenge is guaranteeing nursing representation lasts, and the nurses' needs in offering quality care are advocated.

This type of study is vital since it may benefit the informatics field by signifying future research growth. Early or new career investigators can create a landscape for developing a basis of their

learning within the health informatics field in this study. Research in the health information domain is not entirely new; however, the investigator supported the necessity for exploring and improving some emerging sub-fields of health informatics in this current research. This situation may offer an understanding that motivates practitioners and other researchers in the health informatics field by proposing new research areas on advanced health systems, their users, and their user settings. The researcher considered the requisite for more applied and theoretical research to participate in the health informatics field's maturity; a significant subgroup of information systems research.

Nursing informatics in New Zealand developed and was active through the period of intense change and increased dependence on technology in healthcare (Elers, 2018). Afterward, nursing informatics took the top position in this country for informatics; however, the stakeholders saw the significance of having a combined health informatics focus. Therefore, the combination with other major informatics groups led to the development of HINZ. This group and its forerunners focused on enhancing health informatics, offering an opportunity for education and enhancing the suitable use of health informatics. These groups offered a foundation to ensure informatics was integrated into the more comprehensive health approach. With time, New Zealand went through several health reforms, which have led to the present structure of the IT Health Board and National Health Board who have set the strategy (Goodyear-Smith & Ashton, 2019). Currently, most people have realised that clinicians should be engaged at a strategic level to enhance information and technology's significance in impacting positive health results.

Informatics is essential as it encompasses the representation, processing, and communication of natural and engineered systems. The whole idea is projected to transform information. It also strives to describe scientific advancements and occurrences using new concepts. Health informatics is critical as it helps in bettering the information base. This is made possible by helping to fill the gaps left by researching to acquire information, storing it for future use,

retrieving the information, and using it to ensure better collaboration between healthcare practitioners and patients.

5.1 Limitations

One of the challenges for this study was collecting resources based on the major themes and managing to outline a theory explaining the New Zealand health informatics landscape within a five-year period. Identifying the information was also challenging, especially getting diverse resources and practitioner data on the information technologies – therefore the dataset was limited to forty-seven studies.

5.2 Future Research

There are ever dynamic changes worldwide, with new issues every single time. As a result, the present themes will help address the challenges practitioners face seeking ways to help the people through further studies. The materials that have been reviewed in this study form the basis of the solutions to the challenges that will be faced soon. The issues seem to be connected so that the knowledge gathered can help seek solutions to the challenges that are about to come or will come in the near future; hence, the information already collected is crucial.

In addition, the present study has opened up the need for further research to address a few existing gaps that are left unfilled. After performing this research, the remaining questions that the researcher had were:

What are the patient information needs?

All the patient's information, including the age and health, is recorded and can be accessed for use whenever the patient is admitted to the hospital.

What is the primary information needed for the users?

The information can be easily accessed by the different individuals who need it. With the patient's information recorded and easily accessible, it is available to use whenever needed.

Objectives of Health Information Analysis

The goals and objectives of health informatics are discussed in this section.

Measures of Quality Controls. Therefore, conducting a future study with a more scientific method is essential to have a detailed examination to address these issues. However, the current research is a good start for New Zealand health informatics dialogue, which has not been investigated before and the initial step for more detailed analysis.

References

Alegría, M., NeMoyer, A., Bagué, I. F., Wang, Y., & Alvarez, K. (2018). Social determinants of mental health: Where we are and where we need to go. *Current Psychiatry Reports*, *20*(11), 1-13.

Al-Qirim, N. Championing telemedicine adoption and utilization in healthcare organizations in New Zealand. *International Journal of Medical Informatics*, 76, 1 (2007), 42-54.

Asiri, H. (2016, February). An overview of Nursing Informatics (NI) as a profession: How we evolved over the years. In *HEALTHINF* (pp. 200-212).

Babbage, D. R., van Kessel, K., Terraschke, A., Drown, J., & Elder, H. (2020). Attitudes of rural communities towards the use of technology for health purposes in New Zealand: A focus group study. *British Medical Journal Open*, *10*(6), e037892.

Baggott, C., Chan, A., Hurford, S., Fingleton, J., Beasley, R., Harwood, M., ... & Levack, W. M. M. (2020). Patient preferences for asthma management: A qualitative study. *British Medical Journal Open*, *10*(8), e037491.

Behrendt, C. A., Ir, A. J., Debus, E. S., & Kolh, P. (2018). The challenge of data privacy compliant registry-based research. *European Journal of Vascular and Endovascular Surgery*, *55*(5), 601-602.

Belle, A., Thiagarajan, R., Soroushmehr, S. M., Navidi, F., Beard, D. A., & Najarian, K. (2015). Big data analytics in healthcare. *BioMed Research International*, 2015.

Bidargaddi, N., Schrader, G., Klasnja, P., Licinio, J., & Murphy, S. (2020). Designing m-health interventions for precision mental health support. *Translational Psychiatry*, *10*(1), 1-8.

Blakely, T., Atkinson, J., Kvizhinadze, G., Nghiem, N., McLeod, H., Davies, A. & Wilson, N. (2015). Updated New Zealand health system cost estimates from health events by sex, age and proximity to death: Further improvements in the age of 'big data.' *The New Zealand Medical Journal* (Online), 128, 1422, 13.

Bowden, N., Thabrew, H., Kokaua, J., Audas, R., Milne, B., Smiler, K., Stace, H., Taylor, B. & Gibb, S. (2020). Autism spectrum disorder/takiwātanga: An integrated data infrastructure-based approach to autism spectrum disorder research in New Zealand. *Autism*, 24, 8, 2213-2227.

Brabyn, L., & Beere, P. (2006). Population access to hospital emergency departments and the impacts of health reform in New Zealand. *Health Informatics Journal*, 12, 3, 227-237.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Boyle, L., Grainger, R., Hall, R. M., & Krebs, J. D. (2017). Use of and beliefs about mobile phone apps for diabetes self-management: Surveys of people in a hospital diabetes clinic and diabetes health professionals in New Zealand. *JMIR mHealth and uHealth*, 5(6), e85.

Burmeister, O. K., Ritchie, D., Devitt, A., Chia, E., Dresser, G., & Roberts, R. (2019). The impact of telehealth technology on user perception of wellbeing and social functioning, and the implications for service providers. *Australasian Journal of Information Systems*, 23.

Cesnik, B., & Kidd, M. R. (2010). History of health informatics: A global perspective. *Studies in Health Technology and Informatics*, 151, 3-8. http://www.ncbi.nlm.nih.gov/pubmed/20407147

Chang, S. E., & Shen, W. C. (2018). Exploring smartphone social networking services for mobile tourism. *International Journal of Mobile Communications, 16*(1), 63-81.

Chehade, A., & Liu, K. (2018). Structural degradation modeling framework for sparse data sets with an application to Alzheimer's disease. *IEEE Transactions on Automation Science and Engineering, 16*(1), 192-205.

Ching, T., Himmelstein, D. S., Beaulieu-Jones, B. K., Kalinin, A. A., Do, B. T., Way, G. P., ... & Greene, C. S. (2018). Opportunities and obstacles for deep learning in biology and medicine. *Journal of the Royal Society Interface, 15*(141), 20170387.

Cherrington, M., et al. (2020). *Digital asset management: New opportunities from high dimensional data – a New Zealand perspective*. In Advances in Asset Management and Condition Monitoring. Springer, (pp.183-193).

Clyne, B., Cooper, J. A., Boland, F., Hughes, C. M., Fahey, T., & Smith, S. M. (2017). Beliefs about prescribed medication among older patients with polypharmacy: A mixed-methods study in primary care. *British Journal of General Practice, 67*(660), e507-e518.

Collins, E., Britnell, S., Ditzel, L., & Honey, M. (2017). Using curriculum mapping to develop undergraduate nursing informatics: a New Zealand study. DOI:10.23958/ijirms/vol02-i11/19

Cooter, R. D., Barker, S., Carroll, S. M., Evans, G. R., Von Fritschen, U., Hoflehner, H., ... & De Waal, J. (2015). The international importance of robust breast device registries. *Plastic and Reconstructive Surgery, 135*(2), 330-336.

Cummings, E., Bichel-Findlay, J., Procter, P., Hübner, U., Honey, M., & Day, K. (2020). Nursing informatics education: A global perspective. In *Informatics Education in Healthcare* (pp. 153-166). Springer.

De Witte, L., Steel, E., Gupta, S., Ramos, V. D., & Roentgen, U. (2018). Assistive technology provision: Towards an international framework for assuring availability and accessibility of affordable high-quality assistive technology. *Disability and Rehabilitation: Assistive Technology, 13*(5), 467-472. https://doi.org/10.1080/17483107.2018.1470264

Dhillon, J. S., Ramos, C., Wünsche, B. C., & Lutteroth, C. (2011). *Designing a web-based telehealth system for elderly people: An interview study in New Zealand*. IEEE Symposium conducted at the meeting of the 2011 24th International Symposium on Computer-Based Medical Systems (CBMS).

Dhillon, J. S., Wünsche, B. C., & Lutteroth, C. (2012). *Evaluation of a web-based telehealth system: A preliminary investigation with seniors in New Zealand*. Symposium conducted at the meeting of the Proceedings of the 13th International Conference of the NZ Chapter of the ACM's Special Interest Group on Human-Computer Interaction.

Ding, H., Jayasena, R., Maiorana, A., Dowling, A., Chen, S. H., Karunanithi, M., ... & Edwards, I. (2017). Innovative telemonitoring enhanced care programme for chronic heart failure (ITEC-CHF) improves guideline compliance and collaborative care: Protocol of a multicentre randomized controlled trial. *British Medical Journal Open, 7*(10), e017550.

Ekblaw, A., Azaria, A., Halamka, J. D., & Lippman, A. (2016, August). *A case study for blockchain in healthcare: "MedRec" prototype for electronic health records and medical research data*. In Proceedings of IEEE open & big data conference (Vol. 13, p. 13).

Elers, P. (2018). E-healthcare: A critical examination of the patient portal initiative in New Zealand [Doctoral dissertation, Auckland University of Technology].

Eswari, T., Sampath, P., & Lavanya, S. (2015). Predictive methodology for diabetic data analysis in big data. *Procedia Computer Science*, 50, 203-208.

Fylan, F., Caveney, L., Cartwright, A., & Fylan, B. (2018). Making it work for me: Beliefs about making a personal health record relevant and useable. *BMC Health Services Research, 18*(1), 1-12.

Galpottage, P. & Norris, A. (2005). Patient consent principles and guidelines for e-consent: A New Zealand perspective. *Health Informatics Journal*, 11, 1(2005), 5-18.

Gauld, R., Al-wahaibi, S., Chisholm, J., Crabbe, R., Kwon, B., Oh, T., . . . Sohn, S. (2011). Scorecards for health system performance assessment: The New Zealand example. *Health Policy, 103*(2-3), 200-208.

Goodyear-Smith, F., & Ashton, T. (2019). New Zealand health system: Universalism struggles with persisting inequities. *The Lancet, 394*(10196), 432-442.

Gray, S., Ferris, L., White, L. E., Duncan, G., & Baumle, W. (2018). *Foundations of nursing: Enrolled nurses*. Cengage.

Greenhalgh, T., Koh, G. C. H., & Car, J. (2020). Covid-19: A remote assessment in primary care. *British Medical Journal*, 368.

Guk, K., Han, G., Lim, J., Jeong, K., Kang, T., Lim, E. K., & Jung, J. (2019). Evolution of wearable devices with real-time disease monitoring for personalized healthcare. *Nanomaterials, 9*(6), 813.

Hadid, W., Mansouri, S. A., & Gallear, D. (2016). Is lean service promising? A socio-technical perspective. *International Journal of Operations & Production Management*. (Include volume and page numbers)

Harwood, M. ... & Levack, W. M. M. (2020). Patient preferences for asthma management: A qualitative study. *British Medical Journal Open, 10*(8), e037491.

Hashem, I. A. T., Chang, V., Anuar, N. B., Adewole, K., Yaqoob, I., Gani, A., ... & Chiroma, H. (2016). The role of big data in smart city. *International Journal of Information Management, 36*(5), 748-758.

Hemsley, B., Rollo, M., Georgiou, A., Balandin, S., & Hill, S. (2018). The health literacy demands of electronic personal health records (e-PHRs): An integrative review to inform future inclusive research. *Patient Education and Counseling, 101*(1), 2-15.

Hersh, W. R., & Hoyt, R. E. (2018). *Health informatics: Practical guide*. (7th ed.). Lulu.Com.

Hills, A. P., Farpour-Lambert, N. J., & Byrne, N. M. (2019). Precision medicine and healthy living: The importance of the built environment. *Progress in Cardiovascular Diseases, 62*(1), 34-38.

Hisa, I., Jami, K., & Pikin, P. (2019). *Information on IMIA Regional Groups*. (Include publishing details)

Honey, M. L., Skiba, D. J., Procter, P., Foster, J., Kouri, P., & Nagle, L. M. (2017). Nursing informatics competencies for entry to practice: The perspective of six countries. *Studies in Health Technologies and Informatics*, 232, 51-61.

Honey, M., Collins, E., & Britnell, S. (2020). Education into policy: Embedding health informatics to prepare future nurses – New Zealand case study. *Journal of Medical Internet Research Nursing, 3*(1), https://doi.org/10.2196/16186

Honey, M., Skiba, D. J., Procter, P., Foster, J., Kouri, P., & Nagle, L. M. (2017). Nursing informatics competencies for entry to practice: The perspective of six countries. *Studies in Health Technologies Informatics*, 232, 51-61.

Honey, M. L., & Westbrooke, L. A. (2012). *Nursing informatics in New Zealand: From history to strategy*. American Medical Informatics Association. Symposium conducted at the meeting of the NI 2012: 11th International Congress on Nursing Informatics, June 23-27, 2012, Montreal, Canada.

Hübner, U., Shaw, T., Thye, J., Egbert, N., de Fatima Marin, H., Chang, P., . . . Blake, R. (2018). Technology informatics guiding education reform – TIGER: An international recommendation framework of core competencies in health informatics for nurses. *Methods of Information in Medicine, 57*(Suppl 1), e30-e42.

Hunter, I., Haining Ede, G., & Whiddett, R. (2014). Increased electronic information sharing by sexual health services: Confidentiality and consent. *Health Informatics Journal, 20*(1), 3-12.

Hoyt, R. E., & Hersh, W. R. (Eds.). (2018). *Health informatics: A practical guide*. Informatics Education.

Huggan, P. J., Bell, A., Waetford, J., Obertova, Z., & Lawrenson, R. (2017). Evidence of high mortality and increasing burden of sepsis in a regional sample of the New Zealand population. In *Open forum infectious diseases* (Vol. 4, No. 3, p. ofx106). Oxford University Press.

Ikram, R. R. R., Abd Ghani, M. K., & Abdullah, N. (2015). An analysis of health informatics applications. In Traditional Medicine: A review of four Traditional Medicine Systems. *International Journal of Medical Informatics, 84*(11), 988-996. https://doi.org/10.1016/j.ijmedinf.2015.05.007

Jaspers, M. W., Mantas, J., Borycki, E., & Hasman, A. (2017). IMIA accreditation of biomedical and health informatics education: Current state and future directions. *Yearbook of Medical Informatics, 26*(1), 252.

Jensen, R. (2020). *Submission to the digital and data directorate Ministry of Health, New Zealand*. (Include publisher details)

Kiger, M. E., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher, 42*(8), 846-854.

Klasan, A., de Steiger, R., Holland, S., Hatton, A., Vertullo, C. J., & Young, S. W. (2020). Similar risk of revision after kinematically aligned, patient-specific instrumented total knee arthroplasty, and all other total knee arthroplasty: Combined results from the Australian and New Zealand joint replacement registries. *The Journal of Arthroplasty, 35*(10), 2872-2877.

Kux, B. R., Majeed, R. W., Ahlbrandt, J., & Röhrig, R. (2017). Factors influencing the implementation and distribution of Clinical Decision Support Systems (CDSS). Studies in Health Technologies Informatics, 243, 127-131.

Laxman, K., Krishnan, S. B., & Dhillon, J. S. (2015). Barriers to adoption of consumer health informatics applications for health self-management. *Health Science Journal, 9*(5), 1.

Lee, L. Y., Lim, W. M., Teh, P. L., Malik, O. A. S., & Nurzaman, S. (2020). Understanding the interaction between older adults and soft service robots: Insights from robotics and the technology acceptance model. *AIS Transactions on Human-Computer Interaction, 12*(3), 125-145.

Lee, M., Yun, J. J., Pyka, A., Won, D., Kodama, F., Schiuma, G., ... & Zhao, X. (2018). How to respond to the fourth industrial revolution, or the second information technology revolution? Dynamic new combinations between technology, market, and society through open innovation. *Journal of Open Innovation: Technology, Market, and Complexity, 4*(3), 21. https://doi.org/10.3390/joitmc4030021

Litton, E., Guidet, B., & de Lange, D. (2020). National registries: Lessons learnt from quality improvement initiatives in intensive care. *Journal of Critical Care*. (Volume and page numbers?)

Mallett, R., Hagen-Zanker, J., Slater, R., & Duvendack, M. (2012). The benefits and challenges of using systematic reviews in international development research. *Journal of Development Effectiveness, 4*(3), 445-455. https://doi.org/10.1080/19439342.2012.711342

Marr, B. (2017). *Data strategy: How to profit from a world of big data, analytics and the Internet of Things*. Kogan Page.

Martín-Sánchez, F., & Gray, K. (2014). *Recognition of health informatics in Australian standard classifications for research, occupation and education*. Symposium conducted at the meeting of the HIC.

McKenna, R. (2010). Using information and communications technology to enable the exchange of information between New Zealand clinicians and health providers. *New Zealand Medical Journal, 123*(1314), 92-98.

Mackert, M., Mabry-Flynn, A., Champlin, S., Donovan, E. E., & Pounders, K. (2016). Health literacy and health information technology adoption: The potential for a new digital divide. *Journal of Medical Internet Research, 18*(10). https://doi.org/10.2196/jmir.6349

Malasinghe, L. P., Ramzan, N., & Dahal, K. (2019). Remote patient monitoring: A comprehensive study. *Journal of Ambient Intelligence and Humanized Computing, 10*(1), 57-76.

Marent, B., Henwood, F., Darking, M., & EmERGE Consortium. (2018). Ambivalence in digital health: Co-designing an mHealth platform for HIV care. *Social Science & Medicine*, 215, 133-141.

Marra, C. A., Khakban, A., Wilby, K. J., Buckham, R. B., & Anakin, M. (2020). Using best-worst choice methodology in a survey of pharmacists regarding pharmacy practice skills teaching. *American Journal of Pharmaceutical Education, 84*(12).

Martin, C., Shrestha, A., Burton, M., Collins, K., & Wyld, L. (2019). How are caregivers involved in treatment decision-making for older people with dementia and a new diagnosis of cancer? *Psycho-oncology, 28*(6), 1197-1206.

Masic, I., & Pandza, H. (2018). Medical informatics education – past, today and future. *European Journal for Biomedical Informatics, 14*(2), 40-45.

McQuaid, E. L., & Landier, W. (2018). Cultural issues in medication adherence: Disparities and directions. *Journal of General Internal Medicine, 33*(2), 200-206.

Mehta, B. S. (2016). Impact of mobile phone on livelihood of rural people. *Journal of Rural Development, 35*(3), 483-505.

Miah, S. J., Gammack, J. G., Hasan, S., & Hasan, N. (2017, December). *A decision support framework for public healthcare: An approach to follow-up support service*. In Proceedings of the 28th Australasian Conference on Information Systems (ACIS2017). Australasian Conference on Information Systems (ACIS).

Moreira, M.W., Rodrigues, J.J., Korotaev, V., Al-Muhtadi, J. and Kumar, N., (2019). A comprehensive review on smart decision support systems for health care. *IEEE Systems Journal, 13*(3), 3536-3545.

Moro Visconti, R., & Morea, D. (2019). Big data for the sustainability of healthcare project financing. *Sustainability, 11*(13), 3748.

Nicholas, L. (2017). *Work-integrated learning (WIL) practitioners' perceptions of the value of communities of practice*: *A thesis presented in partial fulfillment of the requirements for the degree of Masters of Education in Tertiary Education at Massey University (Manawatū), New Zealand.* [Doctoral dissertation, Massey University].

O'Connor, Y., Andreev, P., & O'Reilly, P. (2020). M-Health and perceived quality of care delivery: A conceptual model and validation. *BMC Medical Informatics and Decision-Making, 20*(1), 1-13.

Okoli, C., & Schabram, K. (2010, 05/05). A guide to conducting a systematic literature review of information systems research. *SSRN Electronic Journal*, 10. https://doi.org/10.2139/ssrn.1954824

Pather, N., Blyth, P., Chapman, J. A., Dayal, M. R., Fleck, N. A., Fogg, Q. A., ... & Lazarus, M. D. (2020). Forced disruption of anatomy education in Australia and New Zealand: An acute response to the Covid-19 pandemic. *Anatomical Sciences Education, 13*(3), 284-300.

Parry, D., Hunter, I., Honey, M., Holt, A., Day, K., Kirk, R., & Cullen, R. (Eds.). (2013). Building an educated health informatics workforce – The New Zealand experience [Conference Paper]. 188, 86-90. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84894256579&doi=10.3233%2f978-1-61499-266-0-86&partnerID=40&md5=371f075ab24d1bc93627424a4343afd8 https://doi.org/10.3233/978-1-61499-266-0-86

Parry, D., Hunter, I., Honey, M., Holt, A., Day, K., Kirk, R., & Cullen, R. (Eds.). (2013). Health informatics community priming in a small nation: The New Zealand experience [Conference Paper]. 192, 950. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84894290658&doi=10.3233%2f978-1-61499-289-9-950&partnerID=40&md5=16c4c04adbe725851d495e74da800290 https://doi.org/10.3233/978-1-61499-289-9-950 (An error message came up with this URL. Blocked access)

Paton, C., Househ, M., & Malik, M. (2013). The challenges of publishing on health informatics in developing countries. *Applied Clinical Informatics, 4*(3), 428.

Paton, C., Margaret, M., Fernandez-Luque, L., & Lau, A. Y. (2012). Self-tracking, social media and personal health records for patient empowered self-care. (Publishing details. Please check)

Peddie, K. A., & Kelly-Campbell, R. J. (2017). How people with hearing impairment in New Zealand use the Internet to obtain information about their hearing health. *Computers in Human Behavior*, 73, 141-151.

Prosperi, M., Min, J. S., Bian, J., & Modave, F. (2018). Big data hurdles in precision medicine and precision public health. *BMC Medical Informatics and Decision Making, 18*(1), 1-15.

Rajabion, L., Shaltooki, A. A., Taghikhah, M., Ghasemi, A., & Badfar, A. (2019). Healthcare big Information Management, 49, 271-289. Data processing mechanisms: the role of cloud computing. International Journal of (This entry has the title of the article and journal information mixed up. Please correct it)

Ramadan, M., Shuqqo, H., Qtaishat, L., Asmar, H., & Salah, B. (2020). Sustainable competitive advantage driven by big data analytics and innovation. *Applied Sciences, 10*(19), 6784.

Reilly, R., Stephens, J., Micklem, J., Tufanaru, C., Harfield, S., Fisher, I., ... & Ward, J. (2020). Use and uptake of web-based therapeutic interventions amongst Indigenous populations in Australia, New Zealand, the United States of America, and Canada: A scoping review. *Systematic Reviews*, 9, 1-17.

Robb, G., Stolarek, I., Wells, L., & Bohm, G. (2017). The state of quality improvement and patient safety teaching in health professional education in New Zealand. (Publication details need to be added)

Rosen, G. (2015). *A history of public health*. Johns Hopkins University Press.

Russ, A. L., & Saleem, J. J. (2018). Ten factors to consider when developing usability scenarios and tasks for health information technology. *Journal of Biomedical Informatics*, 78, 123-133.

Scott, P. J., Rigby, M., Ammenwerth, E., McNair, J. B., Georgiou, A., Hyppönen, H., ... & Hackl, W. (2017). Evaluation considerations for secondary uses of clinical data: Principles for an evidence-based approach to policy and implementation of secondary analysis: A position paper from the IMIA Technology Assessment & Quality Development in Health Informatics Working Group. *Yearbook of Medical Informatics, 26*(1), 59.

Sepehri, F., Langarizadeh, M., Sharifi, L., Azizi, G., Safdari, R., & Aghamohammadi, A. (2019). Development of a guideline-based decision support system to diagnosis of primary immunodeficiency diseases. *Frontiers in Health Informatics, 8*(1), 11.

Siricharoen, W. V. (2015). *Infographic role in helping communication for promoting health and well-being*. Symposium conducted at the meeting of the Conference: Proceedings of the 2nd international conference on computer science, computer engineering, and education technologies (CSCEET2015). Kuala Lumpur, Malaysia.

Singh, K., Singh, K., & Aziz, A. (2018). Congestion control in wireless sensor networks by the hybrid multi-objective optimization algorithm. *Computer Networks*, 138, 90-107.

Sligo, J., Jones, B., Davies, C., Egan, R., Ingham, T., Hancox, R. J., & Richards, R. (2019). The experiences of young people with chronic illness in New Zealand: A qualitative study. *Child: Care, Health and Development, 45*(5), 660-669.

Steinhubl, S. R., Muse, E. D., & Topol, E. J. (2015). The emerging field of mobile health. *Science Translational Medicine, 7*(283), 283rv3-283rv3.

Sun, Q., Wang, N., Li, S., & Zhou, H. (2018). Local spatial obesity analysis and estimation using online social network sensors. *Journal of Biomedical Informatics*, 83, 54-62.

Tan, S., De, D., Song, W. Z., Yang, J., & Das, S. K. (2016). Survey of security advances in smart grid: A data-driven approach. *IEEE Communications Surveys & Tutorials, 19*(1), 397-422.

Tandon, A., Dhir, A., Islam, N., & Mäntymäki, M. (2020). Blockchain in healthcare: A systematic literature review, synthesizing framework and future research agenda. *Computers in Industry*, 122, 103290.

Thabtah, F. (2019). Machine learning in autistic spectrum disorder behavioral research: A review and ways forward. *Informatics for Health and Social Care, 44*(3), 278-297.

Tulsky, J. A., Beach, M. C., Butow, P. N., Hickman, S. E., Mack, J. W., Morrison, R. S., ... & Pollak, K. I. (2017). A research agenda for communication between health care professionals and patients living with serious illness. *Journal of the American Medical Association Internal Medicine, 177*(9), 1361-1366.

Usak, M., Kubiatko, M., Shabbir, M. S., Viktorovna Dudnik, O., Jermsittiparsert, K., & Rajabion L. (2020). Health care service delivery based on the internet of things: A systematic and comprehensive study. *International Journal of Communication Systems, 33*(2), e4179.

Vaismoradi, M., Jones, J., Turunen, H., & Snelgrove, S. (2016). Theme development in qualitative content analysis and thematic analysis. (Publishing details. Please check)

Valdez, A. C., & Ziefle, M. (2019). The users' perspective on the privacy-utility trade-offs in health recommender systems. *International Journal of Human-Computer Studies*, 121, 108-121.

Varsi, C., Nes, L. S., Kristjansdottir, O. B., Kelders, S. M., Stenberg, U., Zangi, H. A., ... & Eide, H. (2019). Implementation strategies to enhance the implementation of eHealth programs for patients with chronic illnesses: Realist systematic review. *Journal of Medical Internet Research, 21*(9), e14255.

Verma, P., & Sood, S. K. (2018). Fog-assisted-IoT enabled patient health monitoring in smart homes. *IEEE Internet of Things Journal, 5*(3), 1789-1796.

Waidley, E. K. (2018). Patient's perceptions of the nurse's use of technology in care delivery [Doctoral dissertation, Fielding Graduate University].

Warren, D., Paton, C., & Pollock, M. (2010). *Development of a Web 2.0 health innovation exchange for New Zealand Health Informatics Society of Australia*. Symposium

conducted at the meeting of the HIC 2010: Proceedings; 18th Annual Health Informatics Conference: Informing the Business of Healthcare, 24-26 August 2010, Melbourne Convention and Exhibition Centre.

Warren, J. (2019). How will AI change health care delivery? NZ Medical Student Journal, 10-12.

Wan, T., & Gurupur, V. (2020). Understanding the difference between healthcare informatics and healthcare data analytics in the present state of health care management. *Health Services Research and Managerial Epidemiology*, 7, 2333392820952668.

Wang, Y., Kung, L., & Byrd, T. A. (2018). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. *Technological Forecasting and Social Change*, 126, 3-13.

Williamson, K. M., & Muckle, J. (2018). Students' perception of technology use in nursing education. *Computers, Informatics, Nursing, 36*(2), 70-76.

Wilson, W. J., Jayamaha, N., & Frater, G. (2018). The effect of contextual factors on quality improvement success in a lean-driven New Zealand healthcare environment. *International Journal of Lean Six Sigma*. https://doi.org/10.1108/IJLSS-03-2017-0022

Wu, D. T., Chen, A. T., Manning, J. D., Levy-Fix, G., Backonja, U., Borland, D., ... & Gotz, D. (2019). Evaluating visual analytics for health informatics applications: A systematic review from the American Medical Informatics Association Visual Analytics Working Group Task Force on Evaluation. *Journal of the American Medical Informatics Association, 26*(4), 314-323. https://doi.org/10.1093/jamia/ocy190

Yang, C., Huang, Q., Li, Z., Liu, K., & Hu, F. (2017). Big Data and cloud computing: Innovation opportunities and challenges. *International Journal of Digital Earth, 10*(1), 13-53.

Yang, E., Liu, M., Yao, D., Cao, B., Lian, C., Yap, P. T., & Shen, D. (2020). Deep Bayesian hashing with center prior for multi-modal neuroimage retrieval. *IEEE Transactions on Medical Imaging.* (Volume and page numbers?)

Yeonjung, K., Hyangjin, L., Kilsoo, C., & Junghwan, S. (2007). Classification of privacy enhancing technologies on life-cycle of information. Proceedings – The International Conference on Emerging Security Information, Systems, and Technologies, SECURWARE 2007 (pp. 66-70). [4385312] https://doi.org/10.1109/SECUREWARE.2007.4385312

Zahabi, M., Kaber, D. B., & Swangnetr, M. (2015). Usability and safety in electronic medical records interface design: A review of recent literature and guideline formulation. *Human Factors, 57*(5), 805-834.

Zhang, C., & Shahriar, H. (2018, September). *Health data analytics: A health IT application course*. In Proceedings of the 19th Annual SIG Conference on Information Technology Education (pp. 163-163).

Zikos, D., & DeLellis, N. (2018). CDSS-RM: A clinical decision support system reference model. *BMC Medical Research Methodology, 18*(1), 1-14.

Annexure

Annexure A: Thematic Analysis

Theme	Summary of the findings	Comments	Reference
Tele medicine, Telecare, and Telematics	The review found numerous articles published about telemedicine and telecare themes. For example, Hills, Farpour-Lambert, and Byrne (2019) addressed how individuals in New Zealand rapidly adapted to healthy living medicine (HLM) to alleviate health threats. In this regard, HLM-seeker citizens use mobile technologies at a higher rate, enabling personal healthcare control and partnering with healthcare agents or practitioners to have effective healthy living practices. Significantly, such technologies are beneficial with medication and surgery with potential risks of adverse impacts if there are dangers from complicated infections and poor health habits. The Telehealth system was established, and its usability was assessed for use in New Zealand.	Telemedicine and telecare topics are significant areas that depict knowledge development promises in this field.	Hills, A. P., Farpour-Lambert, N. J., & Byrne, N. M. (2019). Precision medicine and healthy living: The importance of the built environment. *Progress in Cardiovascular Diseases*, *62*(1), 34-38.
Big Data	This review found that many studies were published about big data in New Zealand. For example, data analytics frameworks purposed for prediction analysis are expected in assessing an extensive health dataset. Hu et al. (2017) defined the comprehensive data analytics framework based on cloud computing integrated into smart devices and GIS for taking and visualising big data. A predictive model for health shocks supported the study using various households' inaccessible rural areas within New Zealand. A description of the extensive data-enabled system purposed at creating a health status prediction method that adopted big data processing	Telecare and telemedicine topics in health informatics are essential topics, revealing promises for future knowledge development in the field.	Yang, C., Huang, Q., Li, Z., Liu, K., & Hu, F. (2017). Big Data and cloud computing: Innovation opportunities and challenges. *International Journal of Digital Earth*, *10*(1), 13-53.

	concentrated on applying the machine learning model. Chiroma et al. (2016) presented data analytics using data mining methods to execute a faster mining tool to detect New Zealand diseases. These researchers used a classification method based on decision trees and cross-validation to locate records before seeking the doctors' advice. Furthermore, Badfar et al. (2019) outlined the effects of data processing and analysing big healthcare data produced in cloud computing for decision-making. Analysis of large-scale data was gathered automatically from a variety of healthcare devices and applications. Consequently, to attain better performance and solve scalability issues, a distributed big data system is significant for addressing the data diversities of a cloud setting.		
Education	This review's second-highest number of studies were published based on education in the area of health information systems. For instance, Anakin et al. (2020) described the evaluation of pharmacists' skills and knowledge about informatics in New Zealand and their training requirements to enhance professional and curricular growth. The most up-to-date pharmacy curricula in this country barely address informatics skills and principles; therefore, pharmacists often gain informatics skills and computer literacy through self-study, training, and personal interest. The study of Bohm et al. (2017) supported another example. It analysed the quantity and quality of research by academics in New Zealand in medical informatics about their recently published articles in international specialty journals and explored medical informatics research hotspots in this region.	This study's thematic analysis showed that health informatics became a vital subject of teaching and learning in various regions in New Zealand. There is the necessity of developing research in appropriate pedagogies for effective practices in health informatics education.	Marra, C. A., Khakban, A., Wilby, K. J., Buckham, R. B., & Anakin, M. (2020). Using best-worst choice methodology in a survey of pharmacists regarding pharmacy practice skills teaching. *American Journal of Pharmaceutical Education*, *84*(12).

History of health informatics	This review found the history of health informatics to be important as the discipline encompasses a wide array of activities, products, research and theories. Health informatics is as much a result of evolution as planned philosophy, having its roots in the histories of information technology and medicine. The process of its growth continues so that today's work is tomorrow's history. The historical discussion of the area is its history to date, a report rather than a summation. As well as its successes, the history of health informatics is populated with visionary promises that have failed to materialise despite the best intentions. For those studying the subject or working in the field, the experiences of others' use of Information Technologies for the betterment of health care can provide a necessary perspective.	The thematic analysis revealed that the major events and people form a technological backdrop to health informatics and end with some future thoughts. As a result, the history of health informatics gives an educational overview and the beginnings of the health informatics discipline.	Cesnik, B., & Kidd, M. R. (2010). History of health informatics: a global perspective. *Studies in Health Technology and Informatics*, *151*, 3–8. http://www.ncbi.nlm.nih.gov/pubmed/20407147
Digital health	This review found the third-highest number of studies published based on topic areas about digital health. Young et al. (2020) explained the experience of creating an implantable medical device registry in New Zealand. The project addressed the early adventures of formulating a data-sharing model to execute a medical device registry in various hospitals. De Waal et al. (2015) outlined a mobile health solution aimed at rural citizens' information dissemination, healthcare decision support, and diabetics management support care. Most studies have explored the present situation and issues relating to the growth of the public healthcare workforce system for disease control and prevention in New Zealand. These studies described relevant approaches to address those issues in the future after identifying them using a survey.	The thematic analysis showed that broader digital health topics found in health informatics are another significant area of study, which promises future knowledge development in this field.	Klasan, A., de Steiger, R., Holland, S., Hatton, A., Vertullo, C. J., & Young, S. W. (2020). Similar risk of revision after kinematically aligned, patient-specific instrumented total knee arthroplasty, and all other total knee arthroplasties: Combined results from the Australian and New Zealand joint replacement registries. *The Journal of Arthroplasty*, *35*(10), 2872-2877.

Smart living	This review found various articles published about health informatics literature topics, which were addressing smart living. Internet of Things-based interventions is one of these areas, which was addressed in intelligent technologies. For example, Zhou et al. (2018) came up with a data sensor model to identify, analyse, and estimate obesity. The user is taken as an online social network sensor, which can offer valuable health information. Zhou et al. (2018) established an approach through the Internet of Things to enable data from various sources combined to effectively identify possible anticipatory actions and diagnose patient health status. Other examples describe the research problems linked to human behaviour and recommended explanations regarding healthcare intervention systems in health social networks, suggesting an ontology-based deep learning model. In this regard, Zhou et al. (2018) commented on a health observatory conceptual model based on semantic web to help design, develop, and implement a health observatory process.	This claim indicates that smart systems have encountered early hype and later maturity times in the route to better usage and acceptance, focusing on realistic solutions through a combination of developing technologies to promote IT-enabled health care.	Sun, Q., Wang, N., Li, S., & Zhou, H. (2018). Local spatial obesity analysis and estimation using online social network sensors. *Journal of Biomedical Informatics, 83*, 54-62.
Privacy, security, ethics, and other concerns	The review identified some articles published based on topic areas relating to privacy, security, and ethics in health informatics in New Zealand. For example, Valdez and Ziefle (2019) emphasised the significance and utility of privacy-preserving methods connected to sharing personal health information and differential privacy, analysing diverse sharing situations depending on data recipient and the importance of sharing parameterised privacy, and the type of data. Subsequently, Valdez and Ziefle (2019) conducted research to determine the predictors and prevalence of access to the internet and its search for health information. This study	This situation reveals that most articles did not concentrate on the significance of privacy, security, and ethics issues. Health informatics is the primary field where such concerns are broadly investigated.	Valdez, A. C., & Ziefle, M. (2019). The users' perspective on the privacy-utility trade-offs in health recommender systems. *International Journal of Human-Computer Studies, 121*, 108-121. Ekblaw, A., Azaria, A., Halamka, J. D., & Lippman, A. (2016, August). *A case study for blockchain in healthcare: "MedRec" prototype for electronic health records and medical research data*. In Proceedings of IEEE open & big data conference (Vol. 13, p. 13).

	described more usability determinants, assessing the forms of additional information acquired from specific usability testing, which is considered part of the incorporated clinical prediction rule's development stage. More studies have also been carried out to evaluate the occurrence of navigation-related topics within the Identifying Electronic Health Record (HER) safety and usability. Further research has been conducted on this theme, specifically on patient data privacy and the security of technologies and systems supporting patient health data. In this regard, the literature under this theme primarily explored the technical problems of changing from paper-based patient records to digital ones. Design science, multi-method, survey/questionnaire, and conceptual techniques have been adopted to address the technology-centric security matters revolving around the digitisation of patient records. The analysis suggested that extending the present knowledge in this area to technologies and mobile devices is essential. Lippman et al. (2016) emphasised that researchers should examine the shifting from digital records to mobile devices. They claimed that multi-method approaches could effectively investigate the research problem under this theme. Significantly, in-depth qualitative interviews can enable investigators to expose a deeper understanding of patients' needs, preferences, and values concerning the convenience of medical records on mobile devices (Lippman et al., 2016). Also, design science approaches can be adopted to patients' integrated privacy concerns into the design and execution of safety mobile		

	technologies and systems reinforcing patient records.		
Aged care	The review acquired a variety of studies published regarding topics related to age care in health informatics. For instance, Zahabi, Kaber, and Swangnetr (2015) documented an m-health lifestyle management theory that uses mobile health technology to involve the clients in creating the aging population's self-care. Zahabi, Kaber, and Swangnetr (2015) described an overview of the present study into mobile health applications for aging. The research found that a significant number of mobile health applications for the elderly population have been established to support the care of patients with severe medical conditions, ensure home safety, decrease social exclusion and loneliness, and promote healthy lifestyles (Zahabi, Kaber, & Swangnetr, 2015). This claim implies that aged care has been reinforced with mobile health services to satisfy real needs.	The study on promoting the lifestyle of aged populations has been developing. There is a necessity to enhance literature on aged care and encourage older people's independent support and self-management.	Zahabi, M., Kaber, D. B., & Swangnetr, M. (2015). Usability and safety in electronic medical records interface design: A review of recent literature and guideline formulation. *Human Factors*, *57*(5), 805-834.
Organisational issues	The review found various articles published about the topic area of organisational issues. For instance, Krebs et al. (2017) compared two New Zealand regions to utilise assistive technologies. One of the regions had a cloud-based e-health solution to assist in connecting the digital divide between urban and rural healthcare services, leading towards the provision of appropriate medical diagnoses and management. The research recommended a collective response that may provide intelligence for an effective knowledge ecosystem, big data, knowledge exchange, enhanced health informatics capacities, and situational awareness, validating health informatics experts' complex problems. The other region developed a social media	An exploration of organisational issues indicates that many related studies concentrated on clinical and non-clinical settings developing executing healthcare information systems.	Boyle, L., Grainger, R., Hall, R. M., & Krebs, J. D. (2017). Use of and beliefs about mobile phone apps for diabetes self-management: Surveys of people in a hospital diabetes clinic and diabetes health professionals in New Zealand. *JMIR mHealth and uHealth*, *5*(6), e85.

	platform to offer suitable end-user technology, such as open media that was generally structured based on real users' demand through information systems development technique, which contributed to ethical specifications of design knowledge.		
Clinical and decision support (CDSS) aspects	The review obtained various studies published on topic areas about clinical decision support (CDSS). The survey of Zikos and DeLellis (2018) outlined a text mining-based CDSS for recognising admissions indicated as positive for numerous infections; pulmonary embolism, pneumonia, myeloma, and malignant plasma cell neoplasms, secondary malignant neoplasm of digestive and respiratory organs, colon cancer, breast cancer, and lung cancer. The study utilised an approach for evaluating the data from a combination of various sources of medical records. Based on this claim, Röhrig et al. (2017) identified the significance of patient portals for viewing information and for patients' collaboration with medical centres. Various studies have been conducted to permit data from diverse sources to be put together to diagnose patients' health status better and detect potential anticipatory actions. Furthermore, DSS research is growing faster in other health-oriented fields, including the healthcare supply chain.	This analysis depicts that most of the CDSS articles focused on clinical and non-clinical settings to make decisions.	Zikos, D., & DeLellis, N. (2018). CDSS-RM: A clinical decision support system reference model. *BMC Medical Research Methodology*, *18*(1), 1-14 and Kux, B. R., Majeed, R. W., Ahlbrandt, J., & Röhrig, R. (2017). Factors influencing the implementation and distribution of clinical decision Support systems (CDSS). *GMDS*, 127-131.
Assessment and impact analysis	The review found several articles published based on assessment and impact analysis in health informatics. For instance, Car et al. (2020) revealed an evaluation of practice for primary care. The system essentially explores the factors of patient-level data, patient lists, clinical performance, and recommended actions and assessments. This research utilised an iterative	This situation implies that most of the assessment and impact analysis in health informatics concentrated on clinical and non-clinical settings for HIS implementation.	

	method involving multiple evaluation cycles at diverse phases. Another example of research by Hadid, Mansouri, and Gallear (2016) contributed to the existing literature of the socio-technical model and its relevance and value to health information in New Zealand. The research concentrated on various factors that affect health information, infrastructure and people (PIP), and policy; thus, evaluating how New Zealand compares with other countries based on these factors.		
Build/Use Mobile Health Information Technologies (MHIT)	According to Steinhubl, Muse, and Topol (2015), Use Mobile Health Information Technologies (MHIT) entails the design, development, execution, use, or/and adoption of ISTs in the field of healthcare. The analysis of MHIT review indicated that the study undertaken under this theme used various methodologies, such as multi-method, qualitative research, survey/questioners, mathematical modeling, field experiment, conceptual, and design science to investigate behavioural, design, and technological issues relevant to the use of IT in providing patient care. Existing literature indicated that this one is relatively adequately studied compared to other themes and included many papers. The study in this area has concentrated on technology engagement in healthcare delivery, though the research regarding the direct impacts of HIT on patients is minimal.	Thematic analysis indicated that health information technologies had become one of the researched areas in this field.	Steinhubl, S. R., Muse, E. D., & Topol, E. J. (2015). The emerging field of mobile health. *Science Translational Medicine*, *7*(283), 283rv3-283rv3.
Communication with Health Professionals and Patients	Papers found in this theme explored communication within the healthcare industry and promote the flow of information. Communication was theorised differently within each article. For example, some perceived it as the problems disabled patients encounter when communicating or behavioural relationships	In health informatics, communication with health professionals and patients has emerged as an essential topic that shows a promising future.	Tulsky, J. A., Beach, M. C., Butow, P. N., Hickman, S. E., Mack, J. W., Morrison, R. S., ... & Pollak, K. I. (2017). A research agenda for communication between health care professionals and patients living with

	among the stakeholders. By contrast, others listed the benefits and drawbacks of using various mobile devices in offering healthcare services (Pollak et al., 2017). Further, a variety of methods, such as multi-method, survey/questioner, mathematical modeling, or design science, were used to investigate the information flow and communication issues developing during the performance of patient care. The researchers showed that more study is needed to address how the insight gained in this area on the communication, free flow of information, and education purposed to empower patients can be used to design and execute mobile applications.		serious illness. *JAMA Internal Medicine*, *177*(9), 1361-1366.
Patient Work Flow	Papers found on this theme examined how mobile technologies can maximise patient workflow for quality care and treatment. For instance, research indicates that doctors can make patients' treatment decisions using mobile devices within the shortest time possible. Subsequently, mobile technologies can assist resolving the conflicts between medical policies and treatments (Steinhubl, Muse, & Topol, 2015). All these significances offer efficient ways of providing patients with better quality of care. Similarly, simulation methods, conceptual, and design science have been utilised in the existing literature under this theme. The researcher suggested using simulation techniques, including agent-based modeling, for doing a future study regarding this theme. Investigators can initiate the use of mobile technologies to explore their impact on patient workflow. Concurrently, the nature of medical staff workflow and patient workflow can be simulated to expose the incongruities among them and then investigate	The thematic analysis of this study showed that patient workflow has emerged as another essential topic in New Zealand.	Steinhubl, S. R., Muse, E. D., & Topol, E. J. (2015). The emerging field of mobile health. *Science Translational Medicine*, *7*(283), 283rv3-283rv3.

	their consequences on the quality of care. According to Steinhubl, Muse, and Topol (2015), the primary assumption of the papers under this theme is that doctors and nurses use portable devices when delivering services to offer patients with better quality of care. However, there is the necessity of carrying out future research to validate this assumption. For example, future studies should examine the consequences of using mobile technologies by doctors and nurses on patient workflow to investigate whether they facilitate or disrupt patient care linked to workflow.		
Health Data and System Integration	Papers in this theme have concentrated on the impacts of enhancing integration-friendly infrastructure on MHIT regarding scalability, cost, and use. No papers included directly explored patient care; instead, they reported on the consequences of essential infrastructure when used on MHIT and examined the benefits of system integration in the medical sector. Najarian et al. (2015) claimed that very few researchers had examined the role of data and system incorporation within the healthcare setting through the conceptual method only.	The thematic analysis showed that health data and system integration in health informatics are other significant areas of study that promise future knowledge development in this field.	Belle, A., Thiagarajan, R., Soroushmehr, S. M., Navidi, F., Beard, D. A., & Najarian, K. (2015). Big data analytics in healthcare. *BioMed Research International*, *2015*.
Patient Monitoring	The papers studied in this theme found the issues around offering remote patient monitoring services, especially for elderly people or for those with chronic illnesses. The methods that have been used in this area are qualitative study methods, survey/questionnaire, mathematical modeling, field experiment, conceptual, secondary/archival data, and design science. Although these researches explored the functioning of mobile technologies, such as wearable healthcare monitoring systems or mobile sensors, to gather patients' data, they did	This analysis revealed insufficient research in patient monitoring. Health informatics is the primary field where such concerns are examined.	Malasinghe, L. P., Ramzan, N., & Dahal, K. (2019). Remote patient monitoring: A comprehensive study. *Journal of Ambient Intelligence and Humanized Computing*, *10*(1), 57-76.

	not examine whether or not these techniques satisfied their needs, preferences, and values. Mobile patient monitoring has various advantages, such as constant and instant control of patients' health conditions (Malasinghe, Ramzan, & Dahal, 2019). Concurrently, future research should develop optimal approaches to balancing on-site and remote care. Besides, it should investigate the degree to the combination of remote monitoring and face-to-face visits to enhance patient care quality. There is a need to study the long-term effects of remote monitoring when used on patients. As a result, the designs of such services should be directed by patients' preferences and values.		
Health Information Technology (HIT) Success	Some papers that fall in this theme have exhibited the main factors, which shape HIT failure. By contrast, others have suggested theoretical models that offer a merged opinion of the literature in mobile work in healthcare. Existing literature under this theme used multi-method, qualitative study, and mathematical modeling while exploring the factors connected to the success or failure of HIT. Few papers included in this theme focused on all the vital components (Mobile, Healthcare, and IT). Pounders et al. (2016) maintained that the success and failure of HIT research are directly linked to patient-centred care. Essentially, researchers are advised to offer factors that directly affect the success of technology when used to deliver healthcare services, outlining the association between patient care outcomes and HIT success.	An examination of HIT success indicates that many related studies concentrated on this topic since it has an essential role in this field.	Mackert, M., Mabry-Flynn, A., Champlin, S., Donovan, E. E., & Pounders, K. (2016). Health literacy and health information technology adoption: the potential for a new digital divide. *Journal of Medical Internet Research*, *18*(10), e264.
Mobile Health Delivery	Papers under this theme highlighted the problems of bringing mobile health services physically to the elderly at their residences or low-income	This analysis depicts that most articles focused on mobile health	Mehta, B. S. (2016). Impact of mobile phone on the livelihood of rural

	neighbourhoods, or rural areas. Although the included papers did not explore IT adequately, the combination of mobile technologies and physical mobile vehicles can be an exciting area of future research. Consequently, survey/questionnaire, field experiment, and abstract methods have been used in the included papers on this theme. Further, the papers on this theme are mainly restrained to medical services and the physicality of mobile vehicles. Therefore, the researchers contend that IT-enabled mobile vehicles have a likelihood of serving better the patients in low-income neighbourhoods or those in the rural areas and could lead to a higher quality of care (Mehta et al., 2016). Notably, future research should examine how mobile technologies can impact the design of mobile vehicles while saving time and cost.	delivery to make decisions in clinical settings.	people. *Journal of Rural Development*, *35*(3), 483-505.
HIT Value	The study under this theme concentrated on evaluating HIT value and MHIT. The main outcomes in this theme showed that the present technology has a considerable consequence on patient care. Also, the findings uncovered that IR could assist both patients and healthcare providers who desire to have more control of their health (Rajabion et al., 2020). Additionally, works under this theme concentrated on the impacts of technology on the advantages produced by healthcare providers. Future research should realise the primary benefits mobility adds to the present technology and how it affects patient care delivery.	Similarly, this analysis showed that most articles concentrated on HIT value and showed a promising future.	Usak, M., Kubiatko, M., Shabbir, M. S., Viktorovna Dudnik, O., Jermsittiparsert, K., & Rajabion L. (2020). Health care service delivery based on the internet of things: A systematic and comprehensive study. *International Journal of Communication Systems*, *33*(2), e4179.

Annexure B: Summary of the included articles

Author	Year	Title	Findings
Alegría, NeMoyer, Bagué, Wang, & Alvarez.	2018	Where are we now and where do we need to go in terms of social determinants of mental health?	In health informatics, social determinants should be solved to promote mental health.
Asiri	2016	An overview of Nursing Informatics (NI) as a career: How we've changed over time.	Nursing informatics has encountered historical growth.
Babbage, van Kessel, Terraschke, Drown, & Elder	2020	In New Zealand, rural populations' attitudes towards the use of technology for health purposes.	Most people have a positive attitude towards the role of technology in medical provision. Also, individuals are positive about how technology enhances independence and access to healthcare services.
Baggott, Chan, Hurford, Fingleton, Beasley, Harwood, & Levack	2020	Patient preferences for asthma management: A qualitative study.	The study showed how asthma patients desire the adoption of practices that improves the management of the disease.
Behrendt, Ir, Debus, & Kolh	2018	The challenge of data privacy compliant registry-based research.	Health informatics is likely to support the Data Privacy Complaint Registry.
Belle, Thiagarajan, Soroushmehr, Navidi, Beard, & Najarian	2015	Big data analytics in healthcare.	Big data analytics in healthcare have various challenges, although it could support image, genomics, and signal-based analytics in the future.
Bidargaddi, Schrader, Klasnja, Licinio, & Murphy	2020	Designing m-Health interventions for precision mental health support.	m-Health interventions should be optimised to improve precision mental health support.
Boyle, Grainger, Hall, & Krebs	2017	Surveys of persons in a hospital diabetes clinic and diabetic health professionals in New Zealand on their use of and beliefs regarding mobile phone apps for diabetes self-management.	During blood glucose interventions, apps are most supported by those with diabetes, specifically fulfilling insulin dose calculating function.
Burmeister, Ritchie, Devitt, Chia, Dresser, & Roberts	2019	The impact of telehealth technology on user perception of wellbeing and social functioning, and the implications for service providers.	Telehealth has great benefits for those with low digital literacy and less familiarity with technology since it makes it easier to make changes of behaviour to improve their condition. However, the user interface is the primary concern which accompanys the use of technology.

Chang & Shen	2018	Exploring smartphone social networking services for mobile tourism.	Enjoyment of SNS activity (ESA) and perceived value of smartphone SNS (PVSS) impacts travel advice acquired from smartphone SNS (TTAASS) positively.
Chehade & Liu.	2018	Structural degradation modeling framework for sparse data sets with an application to Alzheimer's disease.	The use of Alzheimer's disease (AD) neuroimaging initiative dataset is associated with satisfactory performance.
Ching, Himmelstein, Beaulieu-Jones, Kalinin, Do, Way, & Greene.	2018	Deep learning in biology and medicine has both advantages and disadvantages.	Deep learning techniques will offer an essential way of aiding or speeding up investigation.
Clyne, Cooper, Boland, Hughes, Fahey, & Smith	2017	Beliefs regarding prescription medications among older polypharmacy patients: A primary care mixed-methods research.	Positive and negative attitudes support strong beliefs during treatment. Also, the doctor-patient relationship is likely to affect beliefs and attitudes towards medication, indicating the significance of developing such an association, which should be applied in de-prescribing.
Collins, Britnell, Ditzel, & Honey	2017	Using curriculum mapping to develop undergraduate nursing informatics: A New Zealand study.	The mapping process indicated where information communication technology skills were taught, those known by the students, and detected the gaps in the target audience's informatics learning and teaching delivery.
Cooter, Barker, Carroll, Evans, Von Fritschen, Hoflehner, & De Waal	2015	The international importance of robust breast device registries.	Most countries had operational registries, which lacked sufficient high data capture to promote effective outcome analysis. Such a challenge was brought by the opt-in consent model and the complexity of data sets.
Cummings, Bichel-Findlay, Procter, Hübner, Honey, & Day	2020	Nursing informatics education: A global perspective.	It is important to address the problems arising from the differences between informatics credibility and digital capability when dealing with nursing informatics education.
De Witte, Steel, Gupta, Ramos, & Roentgen	2018	Assistive technology provision: Towards a global framework for ensuring the availability and accessibility of inexpensive, high-quality assistive technology.	The study established the need to come up with an international standard for assistive technology provision. The development of such standards is likely to have a major effect on assistive technology for individuals with disabilities.
Ding, Jayasena, Maiorana, Dowling, Chen, Karunanithi, & Edwards.	2017	Innovative Tele monitoring Enhanced Care Programme for Chronic Heart Failure (ITEC-CHF) improves guideline compliance and collaborative care: A	Compliance rate coupled with best-practice guidelines for monitoring daily weight is suitable since it reduces general practitioner/emergency department visits and readmissions.

		multicenter randomised controlled trial protocol.	
Fylan, Caveney, Cartwright, & Fylan	2018	Making it work for me: My thoughts on how to make a personal health record useful and meaningful.	Personal Health Record (PHR) inspires people to actively control their information and what they can share. Besides, PHR increases the uptake of health-protective behaviors, self-efficacy and supports a holistic method to offer care and aid behavioural change.
Goodyear-Smith & Ashton	2019	New Zealand health system: Universalism struggles with persisting inequities.	Greater focus has been put on performance targets and individual-level secondary services over addressing poverty-related diseases, obesity, and suicide through primary care, preventive activities, and community-based health promotion.
Gray, Ferris, White, Duncan, & Baumle	2018	Foundations of nursing.	Nursing is a big field that includes health informatics associated with various benefits.
Greenhalgh, Koh & Car	2020	Covid-19: A remote assessment in primary care.	There are various guiding principles for selecting between video and telephone appointments, covid query consultation remotely, and the steps followed when organising follow-up and next steps**.**
Guk, Han, Lim, Jeong, Kang, Lim, & Jung	2019	Evolution of wearable devices with real-time disease monitoring for personalised healthcare.	Recently, there has been the growth of nanomaterials, biocompatible materials, and electronics, which has led to the growth of implantable devices, which promote a diagnosis and prognosis through biomedical devices and small sensors, improving the quality and efficiency of medical services.
Hadid, Mansouri, & Gallear	2016	Is poor service promising? A socio-technical perspective.	Social bundles of poor service have an independent positive effect on the firm financial and operational performance. The results are more effective through an association between social bundles and technical bundles.
Miah, S. J., Gammack, J. G., Hasan, S., & Hasan, N	2017	*A decision support framework for public healthcare: An approach to follow-up support service*. In Proceedings of the 28th Australasian Conference on Information Systems.	A type of mobile health informatics system – Clinical Decision Support System (CDSS).
Hashem, Chang, Anuar, Adewole, Yaqoob, Gani, & Chiroma	2016	The role of big data in the smart city.	Smart-based applications and state-of-the-art communication technologies are used in smart cities. Big data analytics can support smart cities since it can change urban populations at diverse levels.
Sepehri, F., Langarizadeh, M., Sharifi, L., Azizi, G.,	2019	Development of a guideline-based decision support system to diagnosis of	Types of health informatics – CDSS.

Safdari, R., & Aghamohammadi, A.		primary immunodeficiency diseases. Frontiers in health informatics.	
Thabtah	2019	In behavioural research on autistic spectrum disorders, machine learning is being used.	Autistic Spectrum Disorder is a mental condition that reduces communication, linguistic, social, cognitive abilities, and skills.
Tulsky, Butow, Beach, Hickman, Morrison, Pollak, & Mack	2017	A research agenda for health-care providers and people with serious illnesses to communicate.	Poor communication among health care professionals leads to psychological and physical suffering in patients living with serious sicknesses.
Usak, Shabbir, & Kubiatko, Viktorovna Dudnik, Jermittiparsert, & Rajabion	2020	Health service delivery based on the internet of things: A systematic and comprehensive study.	Internet greatly responds to the daily needs of people and organisations, thus influencing low-cost health care services and support, effective supervision of central administration, and realisation of public health.
Vaismoradi, Jones, Turunen, & Snelgrove	2016	In qualitative content analysis and thematic analysis, the theme development is very important.	Qualitative research covers various approaches with a wide variation in ideas, expectations, and investigative rules.
Valdez & Ziefle	2019	The user's perspective on the privacy-utility trade-offs in health recommender system.	Privacy is essential in the field of health, especially when concerns of users may be augmented.
Varsi, Nes, Kristajansdottir, Kelders, Stenberg, Zangi, & Eide	2019	Implementation strategies to enhance the implementation of health programmes for patients with chronic illnesses: A realistic systematic review.	eHealth successfully intervenes for patients with chronic illnesses.
Verma & Sood	2018	Fog-assisted-IoT enabled patient health monitoring in smart homes.	The Fog-assisted-IoT provides a professional and organised approach essential for handling delivery features of healthcare, regarding mobile health and remote patient monitoring.
Wardley	2018	Patient's perception of the nurse's use of technology in care delivery.	Addresses the feeling of technology use in patients concerning the care being received. Further, there is a high impact of technology on nurses and their responsibility to patients.
Wan, & Gurupur	2020	Understanding the difference between healthcare informatics and healthcare data analytics in research in the present state of health care management.	Generally, it assists the thinking of informaticians and data experts employed in healthcare management and practice. There is the provision of future directions linked with healthcare as well.
Wang, Kung, & Byrd	2018	Big data analytics: Understanding its capabilities and potential benefits for healthcare organisations.	There are no health care organisation potential benefits acquired from big data analytics. (Are there not? Can you check the meaning of this

			sentence) Also, the growth of big data analytics is based on technology.
Williamson, & Muckle	2018	Student's perception of technology use in nursing education.	Technology is a significant part of nursing practice, thus including it in the nursing curriculum for students. The approach stimulates active and expressive learning experiences.
Wilson, Jayamaha, & Frater	2018	The effects of contextual factors on quality improvement success in a lean-driven New Zealand healthcare environment.	The effective variables for teamwork include lean actions, respect for people, and inspiring negative factors that determine significant health care effects.
Chen, Wu, Manning, Levy-Fix, Backonja, Borland, & Gotz	2019	Evaluating visual analytics for health informatics applications: A systematic review from the American Medical Informatics Association Visual Analytics Working Group Task Force on Evaluation.	Visual analytics aims at characterising different assessment methods used within the health informatics community.
Yang, Huang, Liu, Li, & Hu	2017	Big data and cloud computing present both opportunities and obstacles for innovation.	Provides abundant data and chances that improve and enable research and decision support submissions for modern-day applications, such as medicine, science, business, and engineering.
Yao, Liu, Yang, Cao, Lian, Yap, & Shem	2020	Deep Bayesian hashing with centre prior for multi-modal neuroimaging retrieval.	Facilitates precision and competence of decision-making in clinical practice by providing physicians with previous cases and conforming treatment records.
Zahabi, Kaber, & Swangnetr	2015	Usability and safety in electronic medical records interface design: A review of recent literature and guideline formulation.	The EMR and EHR usability problems in medical records include control reliability, effective language use, defilement of natural dialog, and effective information presentation.
Zhang & Shahriar	2018	Health data analytics: A health IT application course.	Involves the application of IT-based inventions in health care services delivery, planning, and management.
Zikos & DeLellis	2018	The CDSS-RM is a reference model for clinical decision support systems.	Provides help in clinical decision-making and the necessity of considering humans, cognitive roles of clinical decision-makers, and data relations.

Annexure C: List of articles removed from the analysis

Agrawal, R., & Prabakaran, S. (2020). Big data in digital healthcare: lessons learnt and recommendations for general practice. *Heredity*, *124*(4), 25-534.

Albahri, O. S., Albahri, A. S., Mohammed, K. I., Zaidan, A. A., Zaidan, B. B., Hashim, M., & Salman, O. H. (2018). A systematic review of real-time remote health monitoring system in triage and priority-based sensor technology: Taxonomy, open challenges, motivation, and recommendations. Journal of medical systems, 42(5), 1-27.

Allen-Graham, J., Mitchell, L., Heriot, N., Armani, R., Langton, D., Levinson, M., ... & Wilson, J. W. (2018). Electronic health records and online medical records: an asset or a liability under current conditions? Australian Health Review, 42(1), 59-65.

Baggott, C., Chan, A., Hurford, S., Fingleton, J., Beasley, R., Biesialska, K., Franch, X., & Muntés-Mulero, V. (2020). Big Data analytics in Agile software development: A systematic mapping study. Information and Software Technology, 106448.