

Nursing Informatics' Contribution to One Health

Laura-Maria Peltonen¹, Siobhan O'Connor², Aaron Conway³, Robyn Cook⁴, Leanne M. Currie⁵, William Goossen⁶, Nicholas R. Hardiker⁷, Ulla-Mari Kinnunen⁸, Charlene E. Ronquillo⁹, Maxim Topaz¹⁰, Ann Kristin Rotegård¹¹

¹ Department of Nursing Science, University of Turku and Turku University Hospital, Finland

² Division of Nursing, Midwifery and Social Work, School of Health Sciences, The University of Manchester, UK

³ Lawrence S. Bloomberg Faculty of Nursing, University of Toronto, Canada

⁴ Epsilon Informatics Ltd, United Kingdom and Australia

⁵ Leanne M. Currie, School of Nursing, University of British Columbia, Canada

⁶ Director Results 4 Care B.V., the Netherlands

⁷ School of Human & Health Sciences, University of Huddersfield, UK

⁸ Department of Health and Social Management, University of Eastern Finland, Finland

⁹ School of Nursing, University of British Columbia Okanagan, Canada

¹⁰ School of Nursing, Columbia University, USA

¹¹ VAR Healthcare, Cappelen Damm AS, Norway

Summary

Objectives: To summarise contemporary knowledge in nursing informatics related to education, practice, governance and research in advancing One Health.

Methods: This descriptive study combined a theoretical and an empirical approach. Published literature on recent advancements and areas of interest in nursing informatics was explored. In addition, empirical data from International Medical Informatics Association (IMIA) Nursing Informatics (NI) society reports were extracted and categorised into key areas regarding needs, established activities, issues under development and items not current.

Results: A total of 1,772 references were identified through bibliographic database searches. After screening and assessment for eligibility, 146 articles were included in the review.

Three topics were identified for each key area: 1) education: "building basic nursing informatics competence", "interdisciplinary and interprofessional competence" and "supporting educators competence"; 2) practice: "digital nursing and patient care", "evidence for timely issues in practice" and "patient-centred safe care"; 3) governance: "information systems in healthcare", "standardised documentation in clinical context" and "concepts and interoperability", and 4) research: "informatics literacy and competence", "leadership and management", and "electronic documentation of care". 17 reports from society members were included. The data showed overlap with the literature, but also highlighted needs for further work, including more strategies, methods and competence in nursing informatics to support One Health.

Conclusions: Considering the results of this study, from the literature nursing informatics would appear to have a significant contribution to make to One Health across settings. Future work is needed for international guidelines on roles and policies as well as knowledge sharing.

Keywords

Competence; governance; standards; nursing informatics; One Health

Yearb Med Inform 2023;65-75

<http://dx.doi.org/10.1055/s-0043-1768738>

1 Introduction

There are a number of closely-related definitions for nursing informatics (NI). For example, the International Medical Informatics Association (IMIA) NI group [1] definition states: "Nursing Informatics science and practice integrates nursing, its information and knowledge and their management with information and communication technologies to promote the health of people, families and communities world wide". Internationally, there are different

educational opportunities, clinical roles, recognitions and practical solutions related to the level and extent of clinicians, specialists and researchers working with NI [2]. NI contributes to information and knowledge management, which are key functions in any healthcare setting.

The holistic nature of nursing covers the relationship between the professional and individual elements of integrated care and issues related to the care system [3]. This aligns well with One Health. The World Health Organization (WHO) [4] defines

One Health as "an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems", which "recognizes that the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent." The environment has been central in nursing theories and practice since Florence Nightingale [5] and by later nursing theorists like Jacqueline Fawcett [6] and revitalised in later works focusing on ecological caring [7]. One Digital Health

approaches digital transformation of health ecosystems systematically through health and life sciences covering human and animal health in their environment. Health is a complicated and multifaceted variable composed of all elements in these ecosystems [8]. NIs' relevance to One Health can be explored in many ways. To cover the full breadth of NI, this study considers One Health via four key areas: *education, practice, governance and research*.

Education is the building block of healthcare professions and it is critical to developing competencies in informatics [9]. Several informatics competency frameworks exist to support nurse education, such as the American Nursing Informatics Association standards of practice for NI [10], the International Medical Informatics Association recommendations on biomedical and health informatics [11-12], and the Technology Informatics Guiding Education Reform recommendations of Core Competencies in Health Informatics for Nurses [13-14]. These are used by nurse educators to develop teaching and assessment materials to support students' digital competence [15]. University level master's programmes have also been developed and accredited, based on the IMIA recommendations [16].

Digitalisation has transformed healthcare *practice* for nurses [17]. Nurses' use of electronic health records (EHRs) has been studied from different perspective, e.g., acceptance and attitudes toward EHRs [18-19], competencies related to EHR use [20-21] and EHR usability [22-23]. Clinical decision support (CDS) is used for various purposes e.g., supporting nursing diagnostics, medication management and triage [24]. Most studies on CDSs focus on single conditions within acute care settings. There is a need for a broader focus across the continuum of care and integration into EHR systems [24]. Other examples of technologies used by nurses in practice include mHealth apps [25], telehealth solutions [26], and applications of the Internet of Things [27], to name but a few.

Governance has a multifaceted meaning in health informatics related contexts. ISO 38500 [28] defines governance as a system of directing and controlling. Governance is required to fulfil the responsibilities one has when information technology is

applied in nursing or healthcare. The consideration of governance perspectives on all organisational levels including strategies, tactical approaches and operational management supports effectiveness, efficiency and acceptance of the technologies (ISO 38500). Hence, governance concerns actors, activities and structures around directing and controlling an organisation on local, regional, national and international levels. In informatics, it covers areas such as processes related to data management and analysis, information system architectures, standards and interoperability, system development, testing and production, and determining the effects of such systems in the healthcare space. Research shows the importance of standardised languages and knowledge as the foundation of nursing [29] in producing uniform nursing information [30]. Demands for secondary use of data has increased [31] to better support practice, patient outcomes [32] and nursing management [33].

NI *research* often has a human and a technological aspect. Research should assist in solving problems in nursing information management in all areas of nursing and NI [34]. Key issues cover [35]:

1. Human communication and philosophical reflections about NI;
2. Analytical methods for exploring information processing behaviours, knowledge management, and decision-making of nurses and patients;
3. Analytics to evaluate nursing and care outcomes;
4. Development, use and governance of standardised terminologies;
5. Development of technologies including Information modelling assists in bridging gaps between clinicians and technologists;
6. Implementation of technological solutions in nursing;
7. Technology assessment.

International organisations have worked for decades to improve the competencies, recognition and impact of NI. One of these is IMIA NI, which has 27 society members spread out over the globe. It was established in 1982 [36]. It fosters collaboration among those interested in NI to facilitate development in the field. The group shares

knowledge, experience and ideas with nurses and healthcare providers internationally about the practice of NI and the benefits of enhanced information management and education in healthcare. IMIA NI has four Advisory Panels that correspond to the four key areas that frame the current study: education, research, practice and governance. These Panels scan, summarise and share information and knowledge, advice and recommendations for consideration and possible action. In this way, the Panels help the IMIA NI Board perform its advocacy role on behalf of the nursing profession. IMIA NI assumes responsibility, with a global reach, to improve One Health.

2 Objectives

This study aims to summarise contemporary knowledge in NI related to education, practice, governance and research in advancing One Health.

3 Methods

3.1 Design

The study had two phases - one more theoretical and the other more empirical - with both focusing on the four key areas of NI identified previously: education, practice, governance and research. Scientific literature on recent advancements and areas of interest in NI were explored. Parallel to this, two members of the project team extracted empirical data from IMIA NI society reports and analysed it to determine the needs, status, and advancements of digitisation (NI) in member countries and societies.

3.2 Review Data

PubMed and CINAHL were used to search for recent scientific literature from 2019 to 2022 to capture the current trends in NI that would be relevant to One Health. The search strategy was built on the four key areas. The search strategy and results for each area is presented in Table 1.

Table 1 Search strategy and results per key area.

Key area	Search phrases	Results	Included
Education	Nurs* AND Education AND Informatics (title/abstract)	131	54
	Nurs* AND Education AND Digital Health (title/abstract)	68	
Practice	Nursing, Practice, Informatics	737	11
	Nursing, Practice, Digital Health	484	
Governance	("nursing informatics" AND (govern* OR standard* OR norm OR norms OR terminolog*)) OR ("Nursing Informatics"[MAJR] AND (govern* OR standard OR standards OR norm OR norms OR terminolog*)) OR (("Database Management Systems/organization and administration"[MAJR] OR "Medical Informatics/organization and administration"[MAJR] OR "Electronic Health Records/organization and administration"[MAJR] OR "Health Information Systems/organization and administration"[MAJR]) AND (govern* OR standard OR standards OR norm OR norms OR terminolog* OR interoperab*) AND nurs*)	251	51*
Research	("nursing Informatics" AND research methods AND "One Health") = 0, and ("nursing Informatics" AND research methods) = 0 for Medline, and CINAHL ("nursing Informatics" AND research methods)	MEDLINE = 0 CINAHL = 101	30
Total count:		1,772	146

Inclusion criteria:

- Covers NI from an education, research, governance or practice perspective;
- Relevant to One Health;
- Published after 2019 (to ensure currency);
- In the English language;
- Full text available.

Exclusion criteria:

- Discussion papers, opinions, editorials, commentaries and study protocols;
- Education key area: NI research related to student education;
- Practice key area: Areas not directly related to nursing practice.

3.3 Data Analysis of Review Articles

References were manually screened and evaluated for inclusion. A team of 2-3 researchers were assigned to each key area. Topic modelling (LDA) was done with RStudio (version 4.2.2 (2022-10-31) for Mac) to find common patterns for the classification of their content. Articles were uploaded as PDF files and the "pdftools" package was used to extract the text. Data was preprocessed by removal of numbers, stopwords and punctuation. A set of three topics were identified for each of the four key areas. Topics are not mutually exclusive. The top twenty terms of each topic with the highest

beta values were listed. As many terms within the different lists of different topics were similar (*i.e.*, almost all topics had the terms *nursing* and *informatics*), we emphasised the terms in the lists, which differed from each other when naming each topic under the key areas.

3.4 Data Collection and Analysis of Empirical Data

The empirical data set consisted of annual reports submitted to IMIA NI from the society or country members. This report is based on the IMIA NI strategy. Data were extracted from the 2022 reports and categorised according to the key areas. Extracted items were divided into identified needs, established achievements, issues under development and not current. Consent to use the reports was obtained from the society members. According to national and institutional rules (University of Turku, Finland), ethical review was not needed.

4 Results

A total of 1,772 references were identified through the database searches. After screening and assessment for eligibility, 146

articles were included in the review. This literature data set consisted of 60,303 terms and 1,342 pages of text, with an average length of 9.2 pages. The topic modelling results for the literature included are presented per key area.

4.1 Education

Research on NI *education* relevant to One Health showed the following topics (Figure 1):

1. Building basic NI competence;
2. Interdisciplinary and interprofessional competence;
3. Supporting educators' competence in NI.

The research on building basic competence in NI covered studies with nursing students, related to *e.g.*, knowledge and skills in employing digital systems improved after being exposed to an EHR [37] and levels of digital professionalism [38]. Other studies targeted professionals, *e.g.*, regarding adoption of NI, competency models for professional practice [39] and information literacy training [40], and leadership attributes needed to deliver digital health services [41]. Research under the topic of interdisciplinary and interprofessional competence covered, for example, a conceptual framework for interdisciplinary education in engineering and nursing [42], a

practice framework to support certification, accreditation and education [43] and inter-professional clinical informatics curriculum [44]. Finally, studies exploring development of educators' competence in NI for faculty development, regarded pedagogical evidence [45], barriers and facilitators to implementing NI curricula, professional development among educators [46], and more faculty development to teach more advanced topics e.g., artificial intelligence, data science, and robotics [47].

4.2 Practice

Identified research regarding *practice* relevant to One Health showed the following topics (Figure 2):

1. Digital in nursing and patient care;
2. Evidence for timely issues in practice;
3. Patient-centred safe care

The research on digital in nursing and patient care included e.g., a study outlining key areas to effectively integrate digital technologies into practice: “*Leadership, soft skills in relation to communication, use of digital technologies, remote management of patients and developing understanding of the changes in communication in a digital environment*” [48]. The research on evidence for timely issues in practice covered studies exploring technology use during COVID-19, such as development and impact of a digital vaccination card on nursing and citizens [49] and use of virtual reality to address infection control practice for Personal Protective Equipment (PPE) to simulate real life environments for donning and doffing PPE [50]. Studies categorised under the topic patient-centred safe care included perspectives on communication, integration and use of standardised terminologies to ensure available and validated data, and access to

information for developmental work and assessment of impact on outcomes [51].

4.3 Governance

Identified research on *governance* showed the following three topics (Figure 3):

1. Information systems in healthcare;
2. Standardised documentation in clinical context;
3. Concepts and interoperability.

The topic information systems in healthcare included studies exploring the function, features and architecture of information systems in nursing, from exploring the EHR as a panopticon [52] to research data repositories [53]. The topic standardized documentation in clinical context included research on the application and potential of different terminologies into nursing

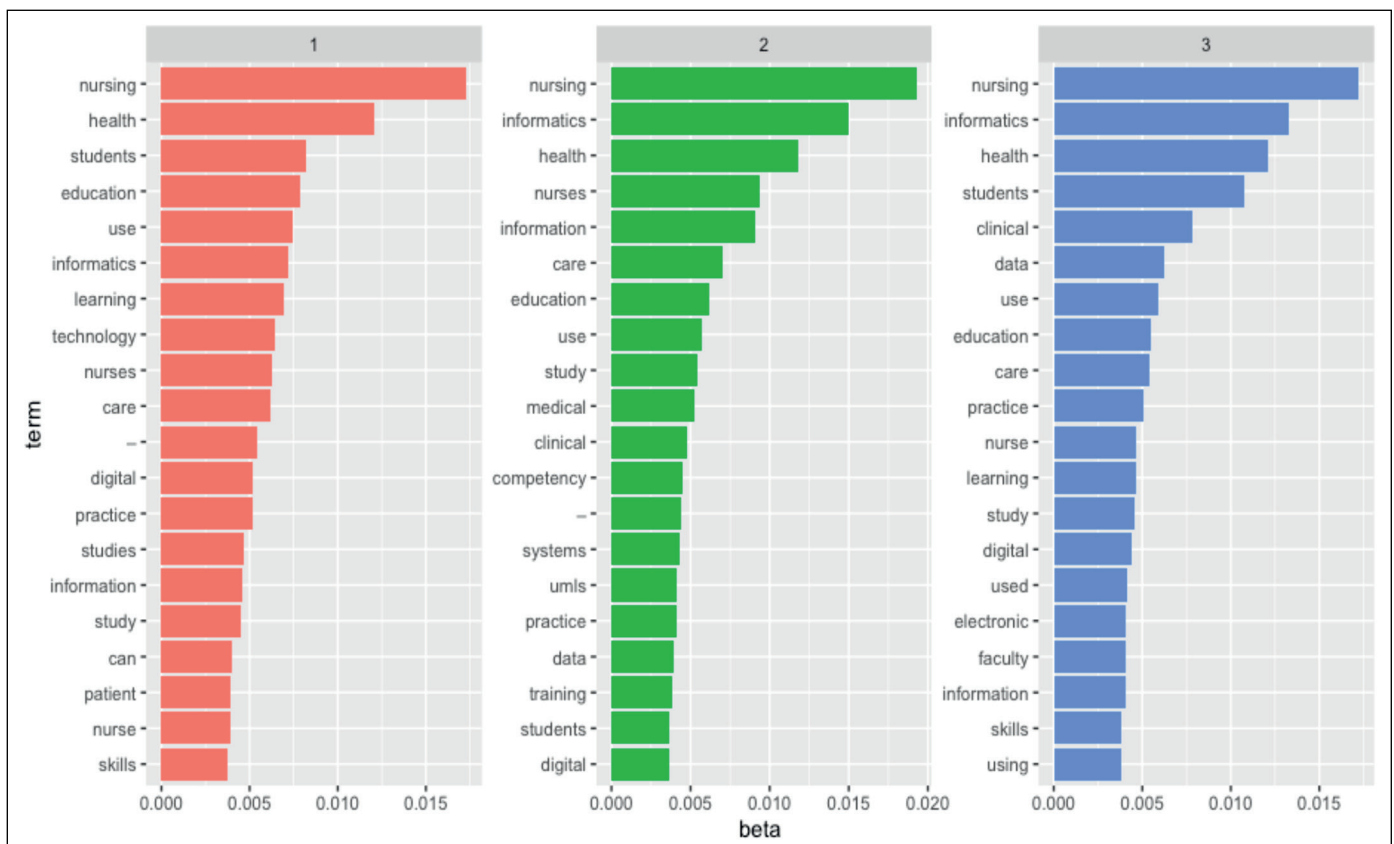


Fig. 1 Topics of research related to education.

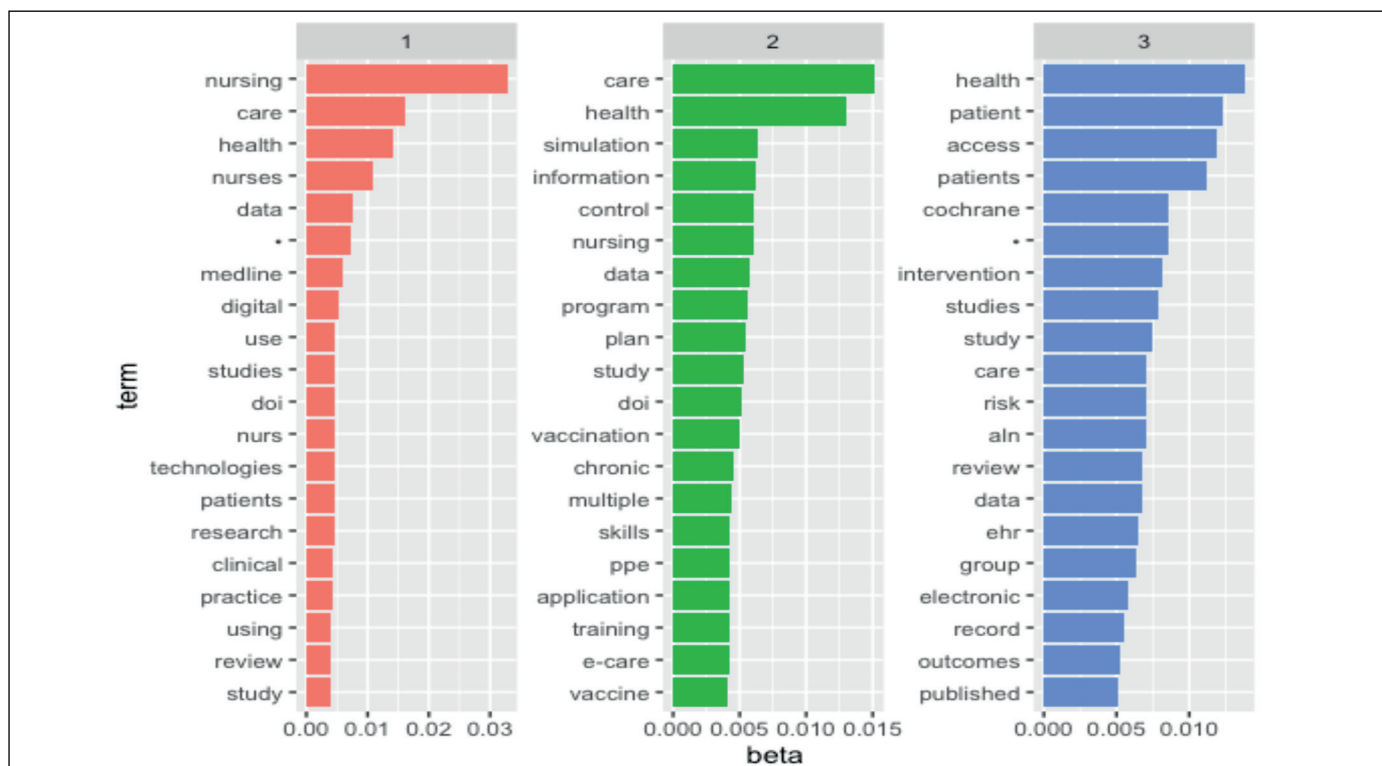


Fig. 2 Topics of research related to practice.

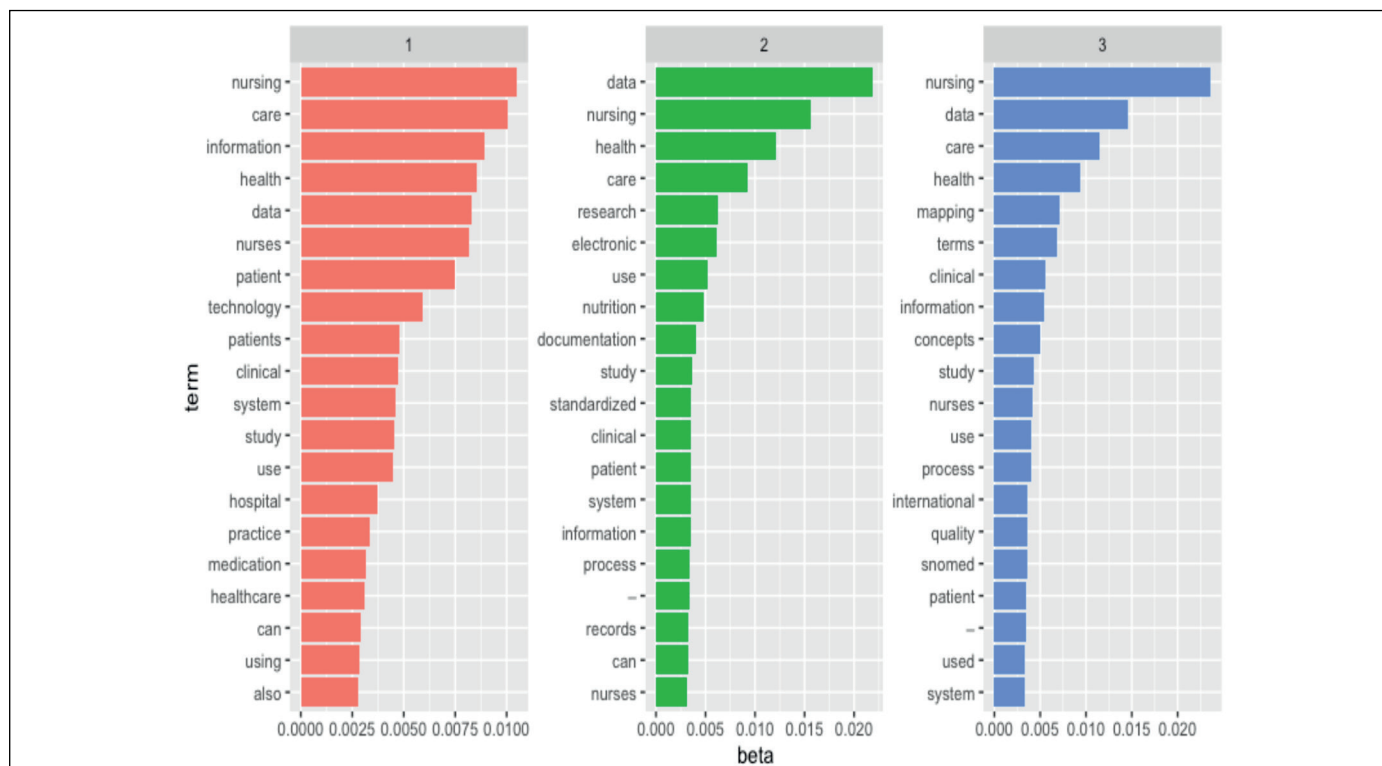


Fig. 3 Topics of research related to governance.

documentation, such as the NANDA-I, NIC and NOC [54-55], the Omaha system [56], the International Classification for Nursing Practice (ICNP), the Clinical Care Classification (CCC) [57], the Finnish Care Classification (FinCC) [58] and SNOMED-CT [59]. The topic concepts and interoperability covered terminologies, development processes and informatics tools necessary to improve interoperability [60-61] and standards for interoperability [62-63].

4.4 Research

Identified topics related to the key area of research included (Figure 4):

1. Informatics literacy and competence for practitioners;
2. Leadership and management;
3. Electronic documentation of care.

The topic informatics literacy and competence for practitioners covered work on education for professionals on different levels from degree curriculum development [64] to continuing education [65] and literacy of service users [66]. The topic leadership and management focused on preparedness and development of informatics competence in nursing leaders [67-69], and the topic electronic documentation of care covered nurses use of EHRs [70] and documentation audits [71] (Figure 4).

4.5 Results from IMIA NI Society Reports

A total of 17 reports from society members across North America (2), Europe (8), Asia and Pacific (7) were included (Australia, Austria, Canada, Finland, India, Japan, Korea, New Zealand, Norway, Philippines, Romania, Slovenia, Sweden, Switzerland, Taiwan, UK and USA). The needs and gaps related to NI or digitalisation in nursing that were identified in the countries and societies were first and foremost related to strengthening capability training and education, as well as increasing the visibility of NI in governance policies. Society members

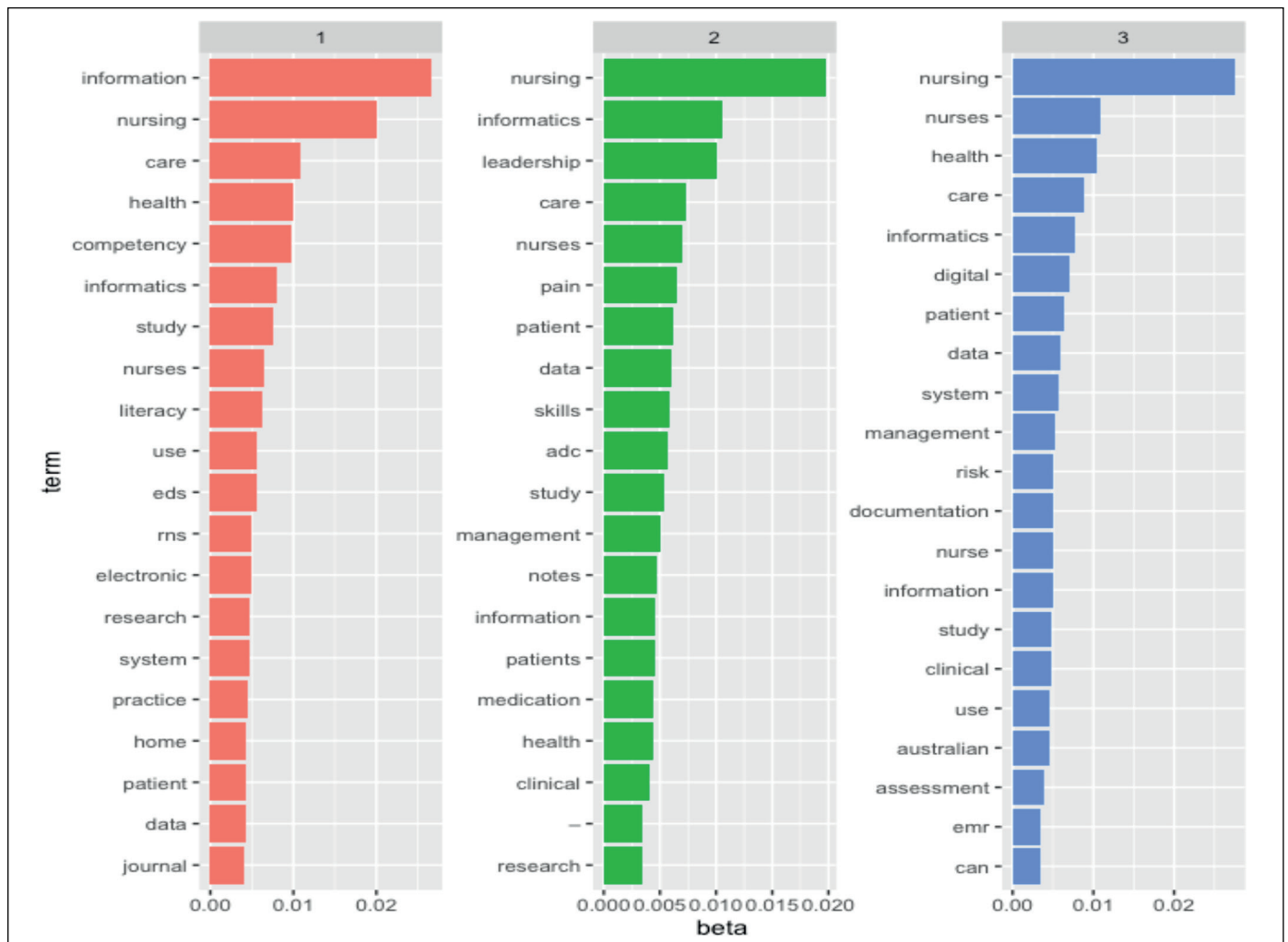


Fig. 4 Topics of data related to research.

reported many established achievements in all four key areas (Table 2). The reach of established activities was most extensive under the key area of practice, across all three regions represented. However, national NI certification, recognition of academic and professional excellence, and governance policies were areas with few reported achievements.

Capability training and education was identified as a top priority for development (reported by 15 of the 17 societies). Especially, the need of educating leaders and educators was highlighted in addition to the need for more general and specialised education in NI and digital health. NI competence needs reached the industry setting, and the importance of nurse-led innovation programs

was emphasised. Further, NI policies were desired by 12 out of the 17 society members. Reported achievements and ongoing work of member societies in the key areas are presented in Table 2 with examples. Finally, the societies across all three regions reported three main areas where IMIA NI could in bridging gaps identified. These focused strongly on networking and knowledge sharing (Table 3)

Table 2 Reported achievements and ongoing work in NI in member societies in the topics of education, practice, research and governance.

	Established Achievements		Work in pogrress		Examples and details
	Total	Region	Total	Region	
Education					
Integration of NI in nursing educational programs /curriculum	9 /17	America (1) Asia-Pacific (4) Europe (4)	8/17	America (1) Asia-Pacific (3) Europe (4)	▪ Nursing organisations drive the politics of NI competencies ▪ Mostly NI is in higher level educations programs ▪ Few have NI in bachelor education and in doctoral programs ▪ EU directive: Informatics is mandatory content of education
National mentoring program for early career NI colleagues	6 /17	America (1) Asia-Pacific (3) Europe (2)	4/17	America (1) Europe (3)	▪ Certification program for NI basic and advanced ▪ Fellowship programs for leaders of NI ▪ CNIO/NI organisations ▪ MIA NI society members and local NI nurses /NI org. members ▪ Medical informatics members mentoring the NI nurses ▪ Ad hoc in conferences, NI meetings
National NI certification	1 /17	America (1)	4/17	America (1) Europe (3)	▪ Nursing organisations explore / have started giving credit for NI achievements and structures for certification
Practice					
EHR in use in clinical practice and/or education	8 /17	America (1) Asia-Pacific (2) Europe (5)	0/17		▪ Improved in interoperability, but lacking for nurses ▪ NI nurses are engaged in the Ministry of health working on data exchange/ interoperability
NI represented on national boards/groups/organisations	14 /17	America (2) Asia-Pacific (4) Europe (8)	0/17		▪ Individual level ▪ Organisational level
Interactions with NI society memmbers	16/17	America (2) Asia-Pacific (6) Europe (8)	0/17		▪ Newsletters ▪ Forum sessions/webinars ▪ Social media ▪ National platforms ▪ Journals ▪ Conferences
Governance					
Governance policies	4/17	America (1) Asia-Pacific (2) Europe (1)	1/17	Europe (1)	▪ Collaboration with institute of health and welfare ▪ Digital social and health services strategy
Policy to support NI and digital health	10/17	America (2) Asia-Pacific (3) Europe (5)	1 /17	Europe (1)	▪ National e-health strategy ▪ Organisational strategy for NI ▪ Few nursing and midwifery focused policies
Promotion of nursing engagement in digital health and informatics	13/17	America (1) Asia-Pacific (5) Europe (7)	0/17	America (1) Asia-Pacific (1) Europe (3)	▪ Nationally (e.g. the health ministry) ▪ Only organisationally ▪ In specific projects (e.g. ICNP as a national standard) ▪ Programs to support nurse leaders in informatics ▪ New NI positions ▪ Early start in some countries

Table 2 (continued) Reported achievements and ongoing work in NI in member societies in the topics of education, practice, research and governance.

	Established Achievements		Work in progress		Examples and details
	Total	Region	Total	Region	
Governance					
Advancement of national level electronic nursing records for data exchange	6/17	Asia-Pacific (2) Europe (4)	5/17	America (1) Asia-Pacific (1) Europe (3)	- Terminology standardisation/ NI strategy driven by government with involvement from NI nurses - Not a topic/existing in 4 societies
National knowledge exchange platform	8/17	America (2) Asia-Pacific (4) Europe (2)	0/17		- Web-pages sharing research results and articles - Nursing knowledge-base / evidence based decision support (spread out nationally) - National NI community of practice - National health information portal
Collaborations between NI organisations and other NI and/or informatics communities	8/17	America (2) Asia-Pacific (2) Europe (4)	1/17	Asia-Pacific (1)	- Formalised (organisational level) - Informal (individual level) - Interdisciplinary (most of the societies) - Between NI organisations and universities/other nursing org, NI groups in the region/ across countries
Research					
Generate and disseminate research knowledge across counties, organisations, and networks	6 /17	Asia-Pacific (3) Europe (3)	0/17		Reporting both nationally and internationally
Organises domestic NI meetings / conferences	13/17	America (2) Asia-Pacific (6) Europe (5)	2/17	Europe (2)	- Mostly annual NI conferences - Joint informatics conferences (interdisciplinary / medicine) - Some implement NI in other main conferences - Seminars / webinars on NI- and/or jointly with medical informatics
Organises international NI meetings/conferences	7 /14	America (2) Asia-Pacific (1) Europe (4)	0/17		- IMIA NI arrangements - Collaborations between countries / regions - Domestic are open to the international audience - Together with medical informatics group
Recognise academic and professional excellence	4/17	Asia-Pacific (2) America (1) Europe (1)	0/17		- Fellowship and awards - Awards programs for nurses in groups that have been excluded from nursing and leadership (e.g., black, indigenous, disability) - Sponsors and funding

Table 3 Support of international community to boost NI nationally.

Topic	Total / Regions		Comments
Creating opportunities for society members to get in contact and learn from each other	13/17	America (2) Asia-Pacific (5) Europe (6)	- Inspiring, but does not reach out to a large number of people - More work is needed to increase engagement and connections locally, regionally, and nationally - A lot of local initiatives in various societies - Examples and ideas from a society in IMIA NI can help demonstrate power of informatics for other countries
Building knowledge sharing platforms to promote NI	12/17	America (1) Asia-Pacific (5) Europe (6)	- Interesting, but language can be a barrier - Lectures - Expert guidance to develop NI locally and empower the nurses
Developing digital health and informatics capability	9/17	America (2) Asia-Pacific (3) Europe (4)	Provide educational material and information material

5 Discussion

Towards the end of the last century, NI emerged as a specialty, with most studies showing more or less case-based results. More recent work internationally has taken as its focus the application of means for knowledge management and sharing, promotion of engagement in NI, and increasing representation of nurses in national health informatics groups. Although the term One Health was not evident in the literature or society reports analysed, our exploration showed numerous examples of the contribution of NI to One Health, as well as also overlap between the research done and the perspectives reported by society members within our NI community on key areas of education, practice, governance and research. However, several gaps in available knowledge within the four key areas were also identified.

The identification and utilisation of the potential of NI is still suboptimal internationally [72]. Many countries have digital health related strategies already implemented, but both the literature and the society reports showed a lack of strategies specific to NI on national levels. Strategies provide systematic ways to reach set goals and they are needed for successful functioning of healthcare organisations due to the constantly evolving environment [73]. National policies and educational programs could support nurses in different settings manage the informatics perspective better [21], but also improve the utilisation of the potential of NI in healthcare. Currently, nurses are working internationally to integrate NI with national health informatics strategies. Interestingly, research and discussion on governance was sparse, mostly covering implementation of specific solutions or standards in individual organisations. In the context of One Health, this highlights a need for a systematic review and theory development with a more in-depth approach to solutions, features and impact of informatics governance on healthcare.

Although there is ample research on education and competencies in NI on different levels (*e.g.*, [20, 65, 74]), few society members reported that NI would be systematically integrated into curricula. Also, accreditation systems for NI are lacking. This highlights a need for diverse educational interventions and increase in competence covering different ac-

tors, such as nurses in clinical practice, nurse informaticians, informatics nurse specialists, nurse researchers and nursing leadership. This aligns with previous research stating that education, certification and roles in NI still seems underdeveloped in many countries [64, 74, 72]. Further, the characteristics of the environment need more consideration as there were differences in reports around the need, necessity and possibilities of education and certification in NI in different societies. More work is needed to find flexible structures to support the evolution of NI in different environments internationally as the extent of applications of NI in societies differ [21, 72].

International guidance for a shared understanding, standardised knowledge and processes would support global capacity building for engaging with the One Health agenda and preparing for the future. Infrastructure and support systems implemented in practice can help follow up on catastrophes, pandemics, complex patient cases in an increasing and ageing population and global risk situation nationally and globally. This will require a tighter collaboration and co-creation across countries, professions and industry. Systems should include and support capability building and succession planning, as well as support health promotion and prevention with respect to the whole health ecosystem. Systems are needed a) to engage the patient, to use their strengths and resources to obtain health and wellness, based on the patients' preferences and perspective [75], and b) to support interaction of professionals, routines and procedures as well as policies, culture and legislation to support health and wellness on a macro system level [76].

There was ongoing discussion in the literature and the society reports around the balance between NI as an independent discipline and the level of collaborative integration of different disciplines under the broad umbrella term of health informatics. This is also seen in prior studies, where the depth of collaboration between disciplines is determined by the task and context [9]. For example, in some societies NI was integrated into health informatics groups, while others had designated groups for NI on national level. While it is important to recognise the specific needs of nursing, it is also important to understand and foster the different levels of collaboration needed to support One Health.

The environment is in the metaparadigm of nursing, but both the literature and the society reports lacked discussion around environmental impacts of digitalisation and health technologies. This aligns with previous research stating a gap in research on the systemic effects of digital health [77]. The provision of tools to permit assessment and development of environmentally sustainable use of technologies allows better contribution to One Health. Policymakers benefit from research in NI for prioritisation of resources for sustainable health and welfare systems internationally.

There are limitations with this study, such as the limited databases and search terms used. A further analysis on the published literature could provide more depth and detail into the key areas of interest. Further limitations include the sampling of collected empirical data, as single respondents' knowledge may be limited to certain areas within a society. However, they are all experts within NI representing their own regions.

6 Conclusions

NI obviously contributes to better patient care and further development of the profession. However, future work is needed to support NI development in the ever-changing healthcare environment and the ongoing proliferation of digital health developments, systems and applications. For practice, actual proof of effectiveness of digital health in patient care is still required. Patient preferences, outcomes and technology assessment is one major area for progress.

International examples and guidelines on roles, infrastructure, competence and education are needed, since NI education, in particular at the bachelor level, *i.e.*, for every practising nurse, is key for the profession and professionalism. Strengthening NI as part of the interdisciplinary health informatics community also requires further development, in particular where governance concerns internationally applied standards for e-health, which are mostly interdisciplinary. In particular where governance concerns internationally applied standards for e-health, that are mostly interdisciplinary.

There is a need for international commitment to develop NI further to better support One Health. Guidelines on strategy develop-

ment and capacity building are needed, but also networks and forums to share information and learn from each other within the community and beyond. It seems that the understanding, needs and expectations of NI differ internationally, and therefore, it will be difficult to develop systems where “one size” fits all. Standardisation between countries with research on suitable level and extent is required. And, as an established specialty, with a clear professional identity, it is time for NI to look beyond its traditional scope, and to contribute to and help drive the One Health agenda.

References

1. The International Medical Informatics Association Nursing Informatics (IMIA NI), 2009. IMIA-NI definition of nursing informatics updated. [Available from: <https://imianews.wordpress.com/2009/08/24/imia-ni-definition-of-nursing-informatics-updated/>].
2. Peltonen L-M, Pruinelli L, Ronquillo C, Nibber R, Lozada Perezmitre E, Block L, et al. The Current State of Nursing Informatics – An International Cross-Sectional Survey. *Finnish Journal of EHealth and EWellfare* 2019;11(3):220–31. doi: 10.23996/fjhw.77584.
3. Kitson AL. The Fundamentals of Care Framework as a Point-of-Care Nursing Theory. *Nurs Res* 2018 Mar/Apr;67(2):99–107. doi: 10.1097/NNR.0000000000000271.
4. World Health Organisation (WHO) 2022. One Health. [Available from: https://www.who.int/health-topics/one-health/#tab=tab_1].
5. Nightingale F. Notes on nursing: What it is and what it is not. Philadelphia, PA: JB Lippincott; 1992/1959.
6. Fawcett J. The metaparadigm of nursing. Present statements and future refinements. *Image J Nurs Sch* 1984 Summer;16(3):84–9. doi: 10.1111/j.1547-5069.1984.tb01393.x.
7. Dahlberg H, Ranheim A, Dahlberg K. Ecological caring-Revisiting the original ideas of caring science. *Int J Qual Stud Health Well-being* 2016 Nov 30;11:33344. doi: 10.3402/qhw.v11.33344.
8. Benis A, Tamburis O, Chronaki C, Moen A. One Digital Health: A Unified Framework for Future Health Ecosystems. *J Med Internet Res* 2021 Feb 5;23(2):e22189. doi: 10.2196/22189.
9. Weber P, Peltonen LM, Junger A. The Essence and Role of Nurses in the Future of Biomedical and Health Informatics. *Stud Health Technol Inform* 2022 Oct 26;300:164–76. doi: 10.3233/SHTI220948.
10. American Nursing Association, 2014. Nursing informatics: scope and standards of practice. 2nd Ed. ANA.
11. Mantas J, Ammenwerth E, Demiris G, Hasman A, Haux R, Hersh W, et al. Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. First Revision. *Methods Inf Med* 2010 Jan 7;49(2):105–20. doi: 10.3414/ME5119.
12. Bichel-Findlay J, Koch S, Mantas J, Abdul SS, Al-Shorbaji N, Ammenwerth E, et al. Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics: Second Revision. *Int J Med Inform* 2023 Feb;170:104908. doi: 10.1016/j.ijmedinf.2022.104908.
13. Hübner U, Shaw T, Thye J, Egbert N, Marin HF, Chang P, et al. Technology Informatics Guiding Education Reform - TIGER. *Methods Inf Med* 2018 Jun;57(S01):e30–e42. doi: 10.3414/ME17-01-0155.
14. Shaw Morawski T, Liang Man Qing. The TIGER Initiative: Global, Interprofessional Health Informatics Workforce Development. In: Hübner U, Wilson Mustata G, Shaw Morawski T, Ball MJ. *Nursing Informatics: A Health Informatics, Interprofessional and Global Perspective*. Springer Nature; 2022. [Available from: <https://link.springer.com/book/10.1007/978-3-030-91237-6#bibliographic-information>].
15. O'Connor S, LaRue E. Integrating informatics into undergraduate nursing education: A case study using a spiral learning approach. *Nurse Educ Pract* 2021 Jan;50:102934. doi: 10.1016/j.nepr.2020.102934.
16. Saranto K, Kinnunen UM. Milestones and Outcomes in Health and Human Services Informatics Education Programmes. *Stud Health Technol Inform* 2022 Oct 26;300:77–92. doi: 10.3233/SHTI220943.
17. Booth RG, Strudwick G, McBride S, O'Connor S, Solano López AL. How the nursing profession should adapt for a digital future. *BMJ* 2021; 373:n1190. doi: 10.1136/bmj.n1190.
18. Salameh B, Eddy LL, Batran A, Hijaz A, Jaser S. Nurses' Attitudes Toward the Use of an Electronic Health Information System in a Developing Country. *SAGE Open Nursing*. 2019;5. doi: 10.1177/2377960819843.
19. Cho Y, Kim M, Choi M. Factors associated with nurses' user resistance to change of electronic health record systems. *BMC Med Inform Decis Mak* 2021 Jul 17;21(1):218. doi: 10.1186/s12911-021-01581-z.
20. Kinnunen U-M, Heponiemi T, Rajalahti E, Ahonen O, Korhonen T, Hyppönen H. Factors Related to Health Informatics Competencies for Nurses - Results of a National EHR Survey. *Comput Inform Nurs* 2019 Aug;37(8):420–9. doi: 10.1097/CIN.0000000000000511.
21. Kaihlanen AM, Gluschkoff K, Kinnunen UM, Saranto K, Ahonen O, Heponiemi T. Nursing informatics competences of Finnish registered nurses after national educational initiatives: A cross-sectional study. *Nurse Educ Today* 2021 Nov;106:105060. doi: 10.1016/j.nedt.2021.105060.
22. Kaipio J, Kuusisto A, Hyppönen H, Heponiemi T, Lääveri T. Physicians' and nurses' experiences on EHR usability: Comparison between the professional groups by employment sector and system brand. *Int J Med Inform* 2020 Feb;134:104018. doi: 10.1016/j.ijmedinf.2019.104018.
23. Kutney-Lee A, Brooks Carthon M, Sloane DM, Bowles KH, McHugh MD, Aiken LH. Electronic Health Record Usability: Associations With Nurse and Patient Outcomes in Hospitals. *Med Care* 2021 Jul 1;59(7):625–31. doi: 10.1097/MLR.0000000000001536.
24. Dunn Lopez K, Gephart SM, Raszewski R, Sousa V, Shehorn LE, Abraham J. Integrative review of clinical decision support for registered nurses in acute care settings. *J Am Med Inform Assoc* 2017 Mar 1;24(2):441–50. doi: 10.1093/jamia/ocw084.
25. Wang Q, Liu J, Zhou L, Tian J, Chen X, Zhang W, et al. Usability evaluation of mHealth apps for elderly individuals: a scoping review. *BMC Med Inform Decis Mak* 2022 Dec 2;22(1):317. doi: 10.1186/s12911-022-02064-5.
26. Nick JM, Roberts LR, Petersen AB. Effectiveness of telemonitoring on self-care behaviors among community-dwelling adults with heart failure: a quantitative systematic review. *JBI Evid Synth* 2021 Oct;19(10):2659–94. doi: 10.11124/JBIES-20-00329.
27. Bai X, Wang Q, Cao S. Application of Infusion Control System Based on Internet of Things Technology in Joint Orthopedics Nursing Work. *J Healthc Eng* 2021 Mar 26;2021:6691258. doi: 10.1155/2021/6691258.
28. ISO IEC. Corporate Governance of Information Technology. ISO IEC 38500: 2008 (E). Geneva: ISO, IEC; 2008.
29. Hardiker NR, Dowding D, Dykes PC, Sermeus W. Reinterpreting the nursing record for an electronic context. *Int J Med Inform* 2019 Jul;127:120–6. doi: 10.1016/j.ijmedinf.2019.04.021.
30. Mykkänen M, Kinnunen UM, Liljamo P, Ahonen O, Kuusisto A, Saranto K. Using standardized nursing data for knowledge generation - Ward level analysis of point of care nursing documentation. *Int J Med Inform* 2022 Nov;167:104879. doi: 10.1016/j.ijmedinf.2022.104879.
31. Saranto K, Kinnunen U-M, Liljamo P, Mykkänen M, Kuusisto A, Kivekäs E. Interprofessional Structured Data: Supporting the Primary and Secondary Use of Patient Documentation. In: Hübner U, Wilson Mustata G, Shaw Morawski T, Ball MJ. *Nursing Informatics: A Health Informatics, Interprofessional and Global Perspective*. Springer Nature; 2022. [Available from: <https://link.springer.com/book/10.1007/978-3-030-91237-6#bibliographic-information>].
32. Westra BL, Subramanian A, Hart CM, Matney SA, Wilson PS, Huff SM, et al. Achieving “meaningful use” of electronic health records through the integration of the Nursing Management Minimum Data Set. *J Nurs Adm* 2010 Jul-Aug;40(7-8):336–43. doi: 10.1097/NNA.0b013e3181e93994.
33. von Gerich H, Moen H, Peltonen LM. Identifying nursing sensitive indicators from electronic health records in acute cardiac care-Towards intelligent automated assessment of care quality. *J Nurs Manag* 2022 Nov;30(8):3726–35. doi: 10.1111/jonm.13802.
34. Goossen WTF. Nursing informatics research. *Nurse Researcher* 2000; 8(2):42–54.
35. Goossen W, Goossen-Baremans A, van der Zel M. Detailed clinical models: a review. *Healthc Inform Res* 2010 Dec;16(4):201–14. doi: 10.4258/hir.2010.16.4.201.
36. Scholes M, Tallberg M, Pluyter-Wenting E. International Nursing Informatics: a history of the first forty years. Swindon UK: the British Computer Society; 2000.
37. Ellis BS, Quayle S, Bailey I, Tishkovskaya S, Spencer J, Richardson R. Students' perceptions on their use of an EHR: pilot questionnaire study. *BMJ Health Care Inform* 2020 Oct;27(3):e100163. doi: 10.1136/bmjhci-2020-100163.
38. O'Connor S, Odewusi T, Smith PM, Booth RG. Digital professionalism on social media: The

- opinions of undergraduate nursing students. *Nurse Educ Today* 2022 Apr;111:105322. doi: 10.1016/j.nedt.2022.105322.
39. Chen Y, Cai Z, Lin B, Yan L, Zheng W, Kuo MC, et al. Developing a professional-practice-model-based nursing organizational informatics competency model. *Int J Med Inform* 2022 Oct;166:104840. doi: 10.1016/j.ijmedinf.2022.
 40. Farokhzadian J, Joupardinejad S, Fatehi F, Falahati-Marvast F. Improving nurses' readiness for evidence-based practice in critical care units: results of an information literacy training program. *BMC Nurs* 2021 May 18;20(1):79. doi: 10.1186/s12912-021-00599-y.
 41. Laukka E, Pölkki T, Kanste O. Leadership in the context of digital health services: A concept analysis. *J Nurs Manag* 2022 Oct;30(7):2763-80. doi: 10.1111/jonm.13763.
 42. Kim HN. A conceptual framework for interdisciplinary education in engineering and nursing health informatics. *Nurse Educ Today* 2019 Mar;74:91-93. doi: 10.1016/j.nedt.2018.12.010.
 43. Gadd CS, Steen EB, Caro CM, Greenberg S, Williamson JJ, Fridsma DB. Domains, tasks, and knowledge for health informatics practice: results of a practice analysis. *J Am Med Inform Assoc* 2020 Jun 1;27(6):845-52. doi: 10.1093/jamia/ocaa018.
 44. Schubert C, Bruce E, Karl J, Nahikian-Nelms M, Pennyman N, Rizer M, et al. Implementing a Novel Interprofessional Clinical Informatics Curriculum. *Comput Inform Nurs* 2022 Jun 1;40(6):411-8. doi: 10.1097/CIN.0000000000000855.
 45. Forman TM, Armor DA, Miller AS. A Review of Clinical Informatics Competencies in Nursing to Inform Best Practices in Education and Nurse Faculty Development. *Nurs Educ Perspect* 2020 Jan/Feb;41(1):E3-E7. doi: 10.1097/01.NEP.0000000000000588.
 46. Honey M, Collins E, Britnell S. Identifying How to Support Nurse Educators Nationally to Teach Nursing Informatics. *Stud Health Technol Inform* 2021 Dec 15;284:124-9. doi: 10.3233/SHTI210683.
 47. Nes AAG, Steindal SA, Larsen MH, Heer HC, Lærum-Onsager E, Gjevjon ER. Technological literacy in nursing education: A scoping review. *J Prof Nurs* 2021 Mar-Apr;37(2):320-34. doi: 10.1016/j.profnurs.2021.01.008.
 48. Isidori V, Diamanti F, Gios L, Malfatti G, Perini F, Nicolini A, et al. Digital Technologies and the Role of Health Care Professionals: Scoping Review Exploring Nurses' Skills in the Digital Era and in the Light of the COVID-19 Pandemic. *JMIR Nurs* 2022 Oct 4;5(1):e37631. doi: 10.2196/37631.
 49. Lopes JP, Dias TMR, Carvalho DBF, Oliveira JF, Cavalcante RB, Oliveira VC. Evaluation of digital vaccine card in nursing practice in vaccination room. *Rev Lat Am Enfermagem* 2019 Dec 5;27:e3225. doi: 10.1590/1518-8345.3058.3225.
 50. Yu M, Yang MR. Effectiveness and Utility of Virtual Reality Infection Control Simulation for Children With COVID-19: Quasi-Experimental Study. *JMIR Serious Games* 2022 May 27;10(2):e36707. doi: 10.2196/36707.
 51. Macieira TGR, Chianca TCM, Smith MB, Yao Y, Bian J, Wilkie DJ, et al. Secondary use of standardized nursing care data for advancing nursing science and practice: a systematic review. *J Am Med Inform Assoc* 2019 Nov 1;26(11):1401-11. doi: 10.1093/jamia/ocz086.
 52. Dillard-Wright J. Electronic health record as a panopticon: A disciplinary apparatus in nursing practice. *Nurs Philos* 2019 Apr;20(2):e12239. doi: 10.1111/nup.12239.
 53. Antonio MG, Schick-Makaroff K, Doiron JM, Sheilds L, White L, Molzahn A. Qualitative Data Management and Analysis within a Data Repository. *West J Nurs Res* 2020 Aug;42(8):640-8. doi: 10.1177/0193945919881706.
 54. da Costa C, Linch GFDC. Implementation of Electronic Records Related to Nursing Diagnoses. *Int J Nurs Knowl* 2020 Jan;31(1):50-8. doi: 10.1111/2047-3095.12219.
 55. De Groot K, De Veer AJE, Paans W, Francke AL. Use of electronic health records and standardized terminologies: A nationwide survey of nursing staff experiences. *Int J Nurs Stud* 2020 Apr;104:103523. doi: 10.1016/j.ijnurstu.2020.103523.
 56. O'Neill AM, Mossing MR, Newcome MD, Miller KB, Monsen KA. Developing Structured Omaha System Goals for Use in an Electronic Health Record. *Comput Inform Nurs* 2019 Dec;37(12):655-61. doi: 10.1097/CIN.0000000000000568.
 57. Lee J, Kang MJ, Garcia JP, Dykes PC. Developing hierarchical standardized home care nursing statements using nursing standard terminologies. *Int J Med Inform* 2020 Sep;141:104227. doi: 10.1016/j.ijmedinf.2020.104227.
 58. Liljamo P, Kuusisto A, Ukkola T, Härkönen M, Kinnunen UM. Updating the Standardized Terminology for Nurses' Daily Documentation. *Stud Health Technol Inform* 2021 Dec 15;284:300-5. doi: 10.3233/SHTI210727.
 59. Kim J, Macieira TGR, Meyer SL, Ansell Maggie M, Bjarnadottir Raga RI, Smith MB, et al. Towards implementing SNOMED CT in nursing practice: A scoping review. *Int J Med Inform* 2020 Feb;134:104035. doi: 10.1016/j.ijmedinf.2019.104035.
 60. Kim H, Eltz AJ. Representing Nursing Data With Fast Healthcare Interoperability Resources: Early Lessons Learned With a Use Case Scenario on Home-Based Pressure Ulcer Care. *Comput Inform Nurs* 2020 Apr;38(4):190-7. doi: 10.1097/CIN.0000000000000564.
 61. Reimer AP, Milinovich A. Using UMLS for electronic health data standardization and database design. *J Am Med Inform Assoc* 2020 Oct 1;27(10):1520-8. doi: 10.1093/jamia/ocaa176.
 62. Chou E, Sockolow PS. Transitions of Care: Completeness of the Interoperability Data Standard for Communication from Home Health Care to Primary Care. *AMIA Annu Symp Proc* 2022 Feb 21;2021:295-304.
 63. Nahm ES, Schoenbaum A, Behm C, Rowen L. Health Information Exchange: Practical Overview and Implications for Nursing Practice. *J Nurs Adm* 2020 Nov;50(11):584-9. doi: 10.1097/NA.0000000000000941.
 64. Cummings E, Moran G, Woods L, Almond H, Procter P, Makeham M, et al. Methodology for the Development of the Australian National Nursing and Midwifery Digital Health Capability Framework. *Stud Health Technol Inform* 2021 Dec 15;284:135-42. doi: 10.3233/SHTI210685.
 65. Ammenwerth E, Hackl WO. Topics for Continuous Education in Nursing Informatics: Results of a Survey Among 280 Austrian Nurses. *Stud Health Technol Inform* 2019;260:162-9.
 66. Cheng L, Zihe Z, Xin S. Understanding Digital Information Needs of Supportive Care for Chinese Children with Cancer and Their Families: The Perspectives of Multi-Stakeholders. *Stud Health Technol Inform* 2021 Dec 15;284:452-4. doi: 10.3233/SHTI210770.
 67. Browne J, Braden CJ. Developing Theoretical Underpinnings for Nursing Workaround Research Using a Mixed Method Approach. *Stud Health Technol Inform* 2021 Dec 15;284:264-8. doi: 10.3233/SHTI210720.
 68. Jing J, Niyomsilp E, Xie L, Jiang H, Li R. Effect of Transformational Leadership on Nursing Informatics Competency of Chinese Nurses: The Intermediary Function of Innovation Self-Efficacy. *Stud Health Technol Inform* 2021 Dec 15;284:275-9. doi: 10.3233/SHTI210722.
 69. Monsen KA, Pesut DJ. Pilot Test of a Theory-Based Instrument to Measure Nursing Informatics Leadership Skills. *Nurs Leadersh (Tor Ont)* 2020 Mar;33(1):100-11. doi: 10.12927/cjnl.2020.26188.
 70. Hobensack M, Ojo M, Bowles K, McDonald M, Song J, Topaz M, et al. Emerging Professionals' Perspectives on Electronic Health Records: A Qualitative Study. *Stud Health Technol Inform* 2021 Dec 15;284:426-30. doi: 10.3233/SHTI210763.
 71. Bail K, Merrick E, Bridge C, Redley B. Documenting patient risk and nursing interventions: record audit. *Aust J Adv Nurs* 2021 Dec-Feb;38;1:36-44. doi: 10.3316/informit.723965483426893.
 72. Peltonen LM, Nibber R, Lewis A, Block L, Prunelli L, Topaz M, et al. Emerging Professionals' Observations of Opportunities and Challenges in Nursing Informatics. *Nurs Leadersh (Tor Ont)* 2019 Jun;32(2):8-18. doi: 10.12927/cjnl.2019.25965.
 73. Ginter PM, Duncan WJ, Swayne LE. The strategic management of health care organizations. John Wiley & Sons; 2018.
 74. Egbert N, Thye J, Hackl WO, Müller-Staub M, Ammenwerth E, Hübner U. Competencies for nursing in a digital world. Methodology, results, and use of the DACH-recommendations for nursing informatics core competency areas in Austria, Germany, and Switzerland. *Inform Health Soc Care* 2019;44(4):351-75. doi: 10.1080/17538157.2018.1497635.
 75. Rotegård AK, Moore SM, Fagermoen MS, Rutland CM. Health assets: a concept analysis. *Int J Nurs Stud* 2010 Apr;47(4):513-25. doi: 10.1016/j.ijnurstu.2009.09.005.
 76. Batt AM, Williams B, Brydges M, Leyenaar M, Tavares W. New ways of seeing: supplementing existing competency framework development guidelines with systems thinking. *Adv Health Sci Educ Theory Pract* 2021 Oct;26(4):1355-1371. doi: 10.1007/s10459-021-10054-x.
 77. Lokmic-Tomkins Z, Davies S, Block LJ, Cochrane L, Dorin A, von Gerich H, et al. Assessing the carbon footprint of digital health interventions: a scoping review. *J Am Med Inform Assoc* 2022 Nov 14;29(12):2128-39. doi: 10.1093/jamia/ocac196.

Correspondence to:
 Laura-Maria Peltonen
 Department of Nursing Science
 20014 University of Turku
 Turku, Finland
 Tel: +358 50 477 1679
 E-mail: laura-maria.peltonen@utu.fi