Solutions and strategies for nursing informatics development

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Abstract

Background and objectives: The purpose of this review study is to determine the situation of executive structures, governmental policies, education, infrastructures for developing the nursing informatics and its applications in order to extract the experiences in developing of nursing informatics and its applications at the national level. *Materials and methods:* This review study conducted in 2011-2012 and information gathered from related organizations' web sites, national related published documents in selected countries. *Results:* Education and promoting competences were an integral part of the development plan. The first step forward providing of information infrastructures is the selection of a nursing minimum data set. For standardized nursing language, the countries follow different approaches. Nursing information systems with various capabilities and decision support mechanisms operate in the form of fully integrated in those countries. *Conclusions:* To develop informatics in nursing, nations should initiate educational programs and follow from a strategic plan, that is included steps toward the providing of needed competencies, standards and policies for coordinated development.

Keywords

Nursing Informatics, Nursing, Education, Infrastructure, Nursing Information System

1. Introduction

Health informatics based on both traditional umbrella health informatics model and Shortlliffe model covers a wide range of applied subfields [1, 2] including medical informatics, consumer health informatics, Bioinformatics, nursing informatics, dental informatics and public health informatics [3-7]. Nursing informatics (NI), a subset of health informatics, has experienced a rapid growth like medical informatics since proposed firstly in 1980. It has been continuously defined by several scientists and scholars with different attitudes [8]. According to Staggers and Bagley [9], "the definitions provided for nursing informatics has evolved from IT-oriented definitions of conceptually-oriented and finally role-oriented definitions". One of the most well known conceptual-oriented definitions have been provided by Turley. Accordingly, "nursing informatics is a science which integrates

information and computer sciences as well as cognitive science with the nursing"[10, 11]. From this viewpoint, it seems that the cognitive science is in relation to aspects of the knowledge work of nurses in decision-making and problem-solving processes and has focused on how data and information are represented, processing, storing and retrieving in the mind [12]. It helps to mimic these mental processes in the artificial world[12, 13].The another definition provided by American Nursing Association is as follows "a specialty that integrates nursing science, computer science, and information science to manage and communicate data, information, and knowledge in nursing practice to support patients, nurses, and other providers in their decision making using information structures, information processes and information technology"[14].Nursing informatics helps nurses in various positions including the administrator, educator, researcher, or even the nurse who cares for the patient in doing their tasks using the main principles of informatics.

It has been proven that nursing informatics have enormous potential for improving the safety [15] and efficiency of nursing care, the effectiveness of nursing education and facilitating decision making in nursing management [16]. To achieve to the potential benefits of nursing informatics, we should know what actions are necessary to develop nursing informatics and what should be done first. In this regard, the aim of the study is to examine the status of administrative structures, governmental policies, and education and information infrastructure to develop nursing informatics and its applications in particular nursing information system, in several countries, which have successful efforts and experiences. The results can be used in other countries such as Iran in which there are still no prominent or reportable efforts in this regard.

2. Methods

2.1. Study Design

This study is a simple review conducted during March 2011 to March 2012. In this study, we studied several countries include Canada, United Kingdom, Australia and Taiwan. The topics studied include following items:

1. Important issues and action plans in the national strategic plan or framework for developing nursing informatics
2. Informatics education for nurses
3. Infrastructures, such as minimum data set and standardized nursing language
4. Nursing Information System

About first three items the required information collected by referring to respective organizations' websites, relevant national published documents in selected countries and searching electronic resources such as Google scholar, PubMed, EBSCO and Elsevier. English documents have selected and studied. In addition, we have communicated with competent individuals and organizations in those countries if needed.

For fourth items, a checklist containing the structure and content features of nursing informatics systems (includes 16 general features and 8 capabilities for decision support) were developed by reviewing the existing literature. The resources were full-text databases such as Google scholar, PubMed, EBSCO and Elsevier. Four experts in Informatics, Nursing and Health Information Management fields confirmed the reliability of the checklist. Then, required information collected by referring to relevant national published documents in selected countries and searching electronic resources and communication with competent individuals and organizations in those countries.

2.2. Selection Criteria

We studied several countries include Canada, United Kingdom, Australia and Taiwan.

They selected from each continent exclude Africa; because there was limited access to reliable information resources about African nations and we haven't received proper cooperation from authorities for providing information needed. These countries selected based on following reasons:

In America, Canada and USA are active in this area. Although the USA has been more successful in particular to develop specialized educational field as nursing informatics in the academic level, there was no evidence about the national strategic plan for nursing informatics in the USA. However, Canada had a national plan for nursing informatics. Therefore, Canada was chosen.

In Europe, Finland, Netherlands and UK have successful efforts. But, none of the countries had a strategic plan. However, related articles, documents and information resources about Finland and Netherlands were in national language, not English. In addition, due to lack of cooperation from related authorities for providing information needed for the present study, these countries not selected. Therefore, UK has been selected.

In Oceania, Australia selected because, it has prepared a national strategic plan for nursing informatics and its other required information were available.

In Asia, countries such as Japan, South Korea and Taiwan have made some progress in the development of informatics for the nursing domain, but little information sources were available in English in Japan and Korea. Whereas in Taiwan required information were in accessed in English. Therefore, Taiwan was selected.

3. Results

3.1. Development Strategic Plan

The studies show that The Canadian Nurses Association (CAN) is one of the pioneers in Canada for the development of nursing informatics activities. Although the Canadian Nursing Informatics Association(CNIA) was officially established to complete projects and plans as well as coordinate the activities and efforts in this regard, The Canadian Nurses Association has been playing the major role in planning the national project about nursing informatics to provide a strategic plan in this regard [17]. According to this plan, the first action plan was a national consensus on a definition for nursing informatics that used in the following action plans. These action plans include the nursing informatics competencies, definition of education strategies and setting priorities (including national database of nursing practitioners, providing nursing data and language standards and support for ICT research projects)[17].Similarly, in Australia, The Australian Nursing Informatics Association(ANIA), as a formal excellent organization, which its main mission is efforts towards realizing priorities to develop nursing informatics, proposed a strategic plan entitled "nursing informatics framework" in collaboration with the Commonwealth Department and the Royal College of Nursing[18]. There

is a generally accepted definition within this framework based on the definition provided by International Medical Informatics Association-NI Special Interest Group (IMIA-NI SIG). Some of the action plans and priorities described in the "Australian Nursing Informatics Framework" are as follows [18]:

- Integration of activities in the nursing information technology field through analyzing the information needed by nurses and defining the minimum data set
- Standardizing the nursing language and developing the required terminologies
- Providing training courses and opportunities for nurses
- Financial support for innovative nursing informatics projects
- Providing guidelines for nursing informatics researchers
- Establishing the nursing knowledge database and developing nursing archetypes

In contrast, at the time of this study, UK had no strategic plan in the field of nursing informatics. Nevertheless, National Health Service (NHS, the UK Department of Health) attempts to start the informatics training courses for nurses, promoting the nurse's informatics skills and granting the ECDL certificate (European Computer Driving License) to provide opportunities for nurses to participate in NHS IT projects [19, 20]. In addition, the meetings held in Scotland on nursing terminology and documenting parts of electronic health records which are relevant to nursing and also evaluation of informatics education status in Wales can all be considered as the UK plans to develop nursing informatics [21-23].

In relation to Taiwan, it seems that this country is developing a strategic plan to identify the objectives, priorities and relevant actions [24]. However, such a plan does not exist yet. Nonetheless, Taiwanese Nursing Informatics Association, founded in 2006.

3.2. Nursing Informatics Education

Education in all countries, even in Taiwan, is a fundamental issue. According to some policy-makers in Taiwan, the development of nursing informatics education is the first step. Therefore, they began some plans in this respect through a national project of nursing informatics competencies [25, 26]. Similarly, other studied countries established nursing informatics competencies as a part of their strategic plan. Table 1 summarized the detailed their results [27-30].

Table 1. *Nursing informatics competencies in selected countries.*

	Executive Domain	Application	Year &Organization	Design	Drafting	Leveling	Categorization
Canada	National	NI education, competencies required by nurses, managers, educators & researchers	1999, CNA	Survey	Literature Review, Grobe's (1986) Taxonomy Schema	Entry Level (Core Competencies), Practicing(More Experienced), Nursing Informatics Specialists(Advanced Level)	Role-Based/ Career, Managers, Educators & Researchers
UK	National	NI education	2006-2010, NHS	Web-based Survey	Literature Review, Self-Developed	No Leveling	Computer Knowledge & Skills/ Informatics Knowledge & Skills/ Awareness And Attitude
Australia	National	NI education, competencies required by nursing staff	2003-2004, ANF & the Queensland University of Technology	Survey	Literature Review, Self-Developed	No Leveling	Computer Knowledge/ Computer Skills/ Informatics Knowledge / Informatics Skills
Taiwan	National	NI education, competencies for staff selection/ evaluation	2007, Taiwan's Ministry of Education and Department of Health	Delphi study	Literature Review, Staggert (2002) Taxonomy Schema	Beginning, Experienced, Specialist & Innovator	Computer Skills/ Informatics Knowledge / Informatics Skills

The strategies to develop the nursing informatics education in Canada are including the following areas: (1) integration of nursing informatics knowledge and skills into the diploma or undergraduate curriculum of nursing. (2) Postgraduate programs as nursing informatics specialty. (3) Formal continuing education programs for nurses in form of NI certificate programs. (4) Informal continuing education programs in nursing informatics or NI non-certificate programs [17]. The Australian framework, exactly mentioned that informatics training and learning programs should be incorporated in the main curriculum of undergraduate and graduate levels [18]. In addition, these

skills not only should be trained in academic courses, but this should be provided through different mechanisms such as professional associations and private educational institutions [18]. Anyway, there is no distinct discipline entitled "nursing informatics" at an academic level in Australia like in Canada and Taiwan. There is no national plan in this regard in the UK, except for special educational programs provided by Nursing Special Group of British Computer Association for nursing students [21]. In addition, there is an ongoing attempts to add informatics courses to the undergraduate nursing curriculum in Wales [22].

All countries recognized that the lack of skilled, competent specialists or faculty who capable of teaching of related topics to the students is main barrier to create a distinct discipline of nursing informatics.

3.3. Information Infrastructure

Data and terminology standards and are considered as a part of the information infrastructures that will guarantee the interoperability [31, 32]. A standard nursing language allows nursing information management and exchange of information on providing nursing care, analysis and comparison of nursing care outcomes throughout the clinical settings over time and research for evidence-based nursing care [16]. The importance of data standards and nursing language in Canada increased with development of Discharge Abstract Database (DAD) and efforts related to electronic health records (EHR) [35]. In line with these concerns, Canadian Nurses Association reached an agreement on a national nursing minimum data set (NMDS) after the establishment of health information: nursing components (HI:NC)[36]. This was the first step to integrate information and facilitate the use of information systems. In addition, International Classification of Nursing Practice (ICNP) had adopted as the unified nursing language in Canada [37]. This led to efforts for localizing the ICNP in Canada [33]. Thereafter, due to the active participation of the International Council of Nurses in the international SNOMED-CT development team to complete the nursing concepts contained in this system, Canada promised to use SNOMED-CT as the only standard clinical terminology in nursing and other clinical areas [33]. The importance of providing a definition for NMDS has been emphasized in the Australian strategic framework.

However, no further progress was achieved in this regard from the community care NMDS project by the Australian community nursing services in 1990 [34, 35]. Generally, SNOMED-CT has been accepted as the national standard of clinical terminology in Australia. NANDA is the only terminology used in nursing. However, there are some efforts toward standardizing nursing language using the ISO reference terminology model (ISO 18104) [36] for nursing which is consists of semantic domains of nursing diagnosis and care and their relationships [37]. The NMDS activities in the UK refer to TELENURSE project conducted in collaboration with some European countries [34, 38]. There is no evidence of new efforts in this regard. In the UK, NANDA and NIC are used in nursing, especially in preparation of standard care plans. In following the adoption of SNOMED-CT in the UK, Association for Common European Diagnoses, Interventions and Outcomes in Europe [39], which is a social network, were developed in order to the realization of the standard nursing language [39].The studies show that the NMDS-I have been adopted in Taiwan as a standard. Furthermore, a preoperative minimum data set consisted of 27 outcomes and 133 interventions developed through an exploratory study [40]. Despite the wide use NANDA, NIC and NOC in Taiwan, ICNP has been introduced as a standard language, and translated into Taiwanese [41]. Table 2 shows the content and the type of NMDS in selected countries [34, 35, 38].

3.4. Nursing Information System

In this respect, one or two systems studied from each country. These systems were included: the Canadian NISS-PCS system which is used in a wide range of long term care and acute care centers in Saskatchewan [42] ExcelCare system which has been conventionally over the years in Australian [43], CareFree system and Nursing management information system (NMIS) in the UK [44] and finally IQ-eNursing system in Taiwan, which has been implemented in several hospitals including Cathay General Hospital [45]. The results showed in Table 3 [42-46].Decision support capabilities, which can be classified into two groups include active and inactive (passive), are other capabilities examined in this study and the related results summarized in Table 4 [42-46].

Table 2. Minimum data set projects in studied countries.

Items	Canada	UK	Australia	Taiwan
Executive domains	National	Multinational	National	International
Application Domain	All Types of Nursing Care Including Long-Term Care	All Types of Nursing Care	Nursing Care in General Hospitals	All Types of Nursing Care
Patient Data Elements	ID/ First & Last Name/ Birth Date(BD)/ Sex/ Ethnic/ Resident	Yes, but details not mentioned	ID/ First & Last Name/ BD/ Sex/ Ethnic	BD/ Sex/ Ethnic/ Resident/ reason for admission
Nursing Data Elements Categories	Client status Nursing intervention Client outcomes Nursing intensity	Nursing diagnosis Nursing intervention Nursing outcome	Nursing diagnosis Goals of nursing care Nursing intervention Client dependency	Nursing diagnoses nursing interventions patient outcomes intensity of care

Items	Canada	UK	Australia	Taiwan
Service and Episode Data Elements	Province/ Institution Record Number/ Physician Identifier/ Consultant Identifier/ Nurse Identifier/Principal Nurse Provider/Admission Date/ Discharge Date/Length of Stay	Institution Type Admission Date Length of Stay Discharge Date	Discharge Agency Identifier/ Referral Source /Date First Encounter/Referral Date /Discharge Date From Hospital/Date First Visit/Discharge Date/Date Last Contact	Care Episode Start and Stop Dates Clinical Service Type Discharge Status
Other Data Elements categories	Payer	No items	Resource Utilization Other Supportive Services	Facility data/ Payment System/Care Personnel data/Ratio of Patients to Personnel

BD=Birth Date

Table 3. General capabilities of selected Nursing Information Systems in studied countries.

Items	Canada	Australia	UK	Taiwan
Clinical Functions				
Integrated to ADT and automatic patient registration	Y	Y	Y	Y
Record of admission assessment and health history	Y	Y	Y	Y
Flexible standard care plan	Y	Y	Y	Y
Product electronic Cardex	Y	Y	Y	Y
Product summary sheets in each 24h	Y	Y	Y	Y
Representation of V/S and I/O data by graph/in time	Y	N	N	Y
Integrate to physiological monitoring equipments	Y	Y	N	Y
Electronic Medicine Administration Record(E-MAR)	Y	N	N	Y
Integrated to RIS, LIS and PIS	Y	Y	Y	Y
Automatic product of discharge summary	Y	Y	Y	Y
Managerial Functions				
Real-time departmental statistics	Y	Y	N	N
Ward map or bed management module	Y	N	N	N
Patient tracing	Y	N	N	Y
Workload measurement tool set	Y	Y	Y	N
Staff scheduling module	Y	Y	Y	N
Periodical reporting of staff activities	Y	Y	Y	Y
Other capabilities				
Integrate to Wireless-based handheld devices	Y	N	N	Y

Y=Yes, the item was available
N=No, the item was not available
ADT=Admission, Discharge, Transfer subsystem in Hospital Information System
V/S=Vital sign I/O=Input and Output Liquids RIS=Radiology Information System
LIS=Laboratory Information System
PIS= Pharmacy Information System

Table 4. Decision Support Capabilities in selected Nursing Information Systems.

Items	Canada	UK	Australia	Taiwan
Active capabilities				
A suggested list of potential diagnoses based on assessment data	Y	Y	N	N
Criticizing of selected diagnoses	N	N	N	N
Clinical pathway or protocols	Y	Y	Y	N
Recommend expected outcomes based on clinical pathways	Y	Y	Y	N
Smart alerting for drug interactions	Y	N	N	Y
Smart alerting for drug errors	Y	N	N	Y
Computerized clinical reminders (CRs)	N	N	N	N
Smart providing of instructions for patient in discharge time	Y	N	N	N
Passive capabilities				
Access to evidence-based databases	N	N	N	N

Y=Yes, the item was available N=No, the item was not available

As the results showed, decision support tools used in studied nursing information systems (e.g. Clinical pathways) to support the diagnosis, interventions, recommendation and altering, usually use the knowledge coded as a rule sets for rule-based reasoning[47]and are not intelligent mechanisms. In addition, the systems examined in the study rarely use passive capabilities such as providing access to knowledge resources and evidence-based databases, perhaps due to the need to connect to the web or other reasons, which we have not examined. [42-46].

4. Discussion

The results indicated that the preparation of a strategic plan on nursing informatics is a continuous slow process. This could accelerate by conducting a general review on

the status of infrastructure, especially data infrastructure and also individual capacities such as competencies to detect weaknesses, needs and existing gap to achieve the expected objectives specified in a national accepted definition of nursing informatics. According to Tan, a strategic informatics plan requires the alignment of objectives with user needs in doing their tasks [48]. All countries examined in the present study founded national associations to lead the efforts and avoid multiple, similar and unnecessary (in parallel) actions. The research conducted by Honey et al. showed that the foundation of a national nursing informatics association would help the development of concepts and their applications in countries and new ideas for further development [49]. Training and promoting skills was the central part of the strategic plan and develop policies in all countries, especially those that had a written leading plan. However, the findings indicate that there are no specific courses in nursing informatics in the universities of the selected countries. As noted previously, the common problem for all countries is that there are no sufficient capacities, including educators who simultaneously are expert in the both nursing and information fields to establish a distinct discipline at academic level. According to Hansa, the important factor in determining the status of education is eligible individuals to teach students or learners [50]. The results support this claim. Therefore, it can be said that training expert faculty in the field of nursing informatics skills and knowledge is a good practice to resolve this issue. Countries do not limit themselves to academic education to promote the required skills of nurses, but all of them agree on the development of training at all possible levels, such as short-term and long-term courses for students and continuing and in-service courses either as certificate or non-certificate courses for nursing staff. The results are consistent with the results of Marin, who believes that academic and continuing educations should be emphasized to develop nursing informatics education [51]. Therefore, both basic levels of nursing education and graduate and continuing education levels should be considered to promote the skills of nurses and other stakeholders dealing with the development and use of technology in the field of nursing informatics.

According to the results, agreement on a set of competencies is a fundamental step. There are different methods for determination of nursing informatics competencies and ranking them. The common point is that computer science, computer skills and informatics knowledge and skills from the basic to advanced levels should receive more attention respectively. Canada has followed a different approach in which the competencies for all responsibilities and possible roles that nurses can play, including care, research, education and management have been defined. Since each of these roles deal with different technologies and requires different knowledge and skills, it seems that this approach is more appropriate and more comprehensive. Nonetheless, this approach will

be useful in the case where the duties and responsibilities of nurses in each of these roles are clearly defined. The results showed that the examined countries have chosen a NMDS in the first step. The NMDS in these countries can be applied in all settings. An important issue that was not addressed and can be considered as a limitation of the present study is how to define the dataset. Neela [52] has identified the methods to define a NMDS in a comprehensive study on it. The methods include a review of clinical records and documentation and Delphi study. However, no comment has been given in the preferred method. As the findings showed, the MDS should include elements, which provide the comparison of the results of nursing care in the same patients in different healthcare centers. We are faced with two problems regarding standardized nursing language. On the one hand, the need for terminologies for standardizing nursing terms and expressions such as diagnosis, problems, interventions and outcomes led to the extensive effort of countries to find the means to integrate them, such as international standard of Omaha [53] and ICNP. This standard is a composite terminology for nursing which facilitates the development and cross mapping between local terms and existing terminologies. ICNP meets those needs of nurses that, not met with existing classification structure and strategies. Nursing diagnoses, interventions and outcomes are the elements of ICNP [54]. Canada and Taiwan have chosen ICNP combinatorial system to resolve this issue. On the other hand, nowadays, electronic data exchange among heterogeneous systems led to the increased use of concept-oriented terminologies. This feature is not observed in NANDA, NIC and NOC. According to Hardiker et al., these are enumerative systems. This means that all possible terms have been exactly listed [55]. In other words, a restricted set of pre-coordinated terminological phrases arranged in a list or organized alphabetically or hierarchically [55]. The solution is to use the terminology model, which is the representation of a set of concepts and their relationships, such as ISO reference terminology model for nursing. This model is useful to describe conventional nursing care terminologies in computerized documentation systems [56]. ISO RTM represents the nursing concepts definitions, the semantic relationships between key concepts and fundamental characteristics [57]. The alternative strategy is mapping between enumerative systems to conceptual-oriented systems such as SNOMED-CT. In this case, SNOMED-CT is referred as the reference terminology [55]. According to the obtained results, Canada and the United Kingdom use this approach. Australia has followed the reference terminology model and recognized ISO RTM as a solution. Therefore, since SNOMED-CT is widely used for medical language and some efforts have been made to complete the nursing components and concepts in this language, it seems that the mapping with SNOMED-CT is likely to avoid future possible problems. In this regard, a study conducted in US on the agreement of experts to reach consensus on an

appropriate approach to develop a common nursing language[32]. The results showed that participants agreed with mapping current terminology with a reference terminology such as SNOMED-CT[32]. The results of this research to support our conclusion. As the results showed, nursing information systems work fully integrated with other sub-systems of hospital information system in the hospitals of the countries examined in this study. Therefore, they are not just computerized documentation systems, but also facilitate data processing and communication tasks of nurses. In the case of documentation of physiological nursing monitoring, the NIS capability in all countries, except for England, for the integrity of the physiological monitoring equipment instead of viewing and reading the patient's physiological status displayed by the monitoring systems and entering the relevant data is an important feature. This can help the correct nursing evaluations. Wager et al. studied the time and quality of the recorded data of vital signs using three different methods. Their results showed that automated data entry from monitoring equipment in the nursing information system is faster and better in terms of quality and accuracy. Manual recording and data entry through bedside mobile terminals were other methods [58].

  In addition, The results of Chang et al showed that all participants stated that quick access to patient information through mobile devices would be very helpful [59]. Other studies have shown that the use of mobile-based software in nursing contributes to improving the efficiency of nursing personnel [60-62].

  Based on the results on the decision support mechanisms in nursing information systems in selected countries, alerting, clinical pathways and recommendations are common mechanisms used in nursing. This is rational, because according to Raghupathi [63], the nature of decision-making in nursing is related to low and middle decision making levels with structured and semi-structured issues or often single agent based problems. At this level, reasoning models are rule-based, thus the decision mechanisms often include reminders, alerting and recommending [63]. These mechanisms use knowledge base, which can contain rule sets, best practice protocols, maps, or clinical pathways [47] such as these exist in the nursing information systems of the countries examined in this study. In the case of rare unstructured nursing decisions, the system should make use of the artificial intelligence techniques such as artificial neural networks, and genetic algorithms [47]. Nonetheless, according to previous studies, nursing information systems can become more helpful by providing passive mechanisms to support decision-making through integrated with nursing portals that provide access to evidence-based databases [64, 65].

5. Conclusion

  In general, there are few scattered efforts to develop informatics in nursing than medicine to provide minimum

requirements, conditions and infrastructure such as education and promoting informatics skills and information as well as technical infrastructure. In these circumstances, it can be concluded from the present study that continued progress in the field of development of nursing informatics systems will be achieved only when countries set targets and follow a strategic plan, which includes the steps towards providing the required competencies, standards and policies for harmonious development. In general, we recommend following procedures:

- Consensus on a definition for nursing informatics
- To Define the informatics competencies for nurses
- To Decide on the providing of qualified and skilled people to teach nurses both in academic level and continuing education programs
- To Determine the nursing minimum data set and unified nursing language as the infrastructure of informatics applications
- Develop and use the standard-based information systems for nurses in their practice
- Develop technical infrastructures needed for the application of technologies such as decision support systems and wireless systems in nursing care, management, research and education

  The results of the present study can help determine best practices and exploiting them by other countries like Iran, which still has not a prominent reportable activity in this regard.

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