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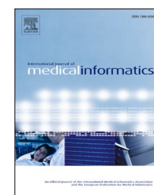

Original article

A multi-perspective approach to developing the Saudi Health Informatics Competency Framework

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A R T I C L E I N F O

Keywords:
Health informatics
Competency framework
Saudi Arabia
Healthcare workforce
Digital health
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A B S T R A C T

Background: Determining the key sets of competencies necessary for a Health Informatics (HI) professional to practice effectively either solo or as a member of a multidisciplinary team has been challenging for the regulator and registration body responsible for the healthcare workforce in Saudi Arabia, which is the Saudi Commission for Health Specialties (SCFHS).

Objective: The aim of this study was to develop a HI competency framework to guide SCFHS to introduce a HI certification program that meets local healthcare needs and is aligned with the national digital health transformation strategy.

Methodology: A two-phase mixed methods approach was used in this study. For phase 1, a scoping review was conducted to identify HI competencies that have been published in the relevant literature. Out of a total 116 articles found relevant, 20 were included for further analysis. For phase 2, Saudi HI stakeholders (N = 24) that included HI professionals, administrators, academics, and healthcare professionals were identified and participated in an online survey, and asked to rank the importance of HI competencies distinguished in phase 1. To further validate and contextualize the competency framework, multiple focus groups and expert panel meetings were undertaken with the key stakeholders.

Results: For phase 1, about 1315 competencies were initially extracted from the included studies. After iterative reviews and refinements of codes and themes, 6 preliminary domains, 23 sub-domains and 152 competencies were identified. In phase 2, a total of 24 experts participated in the online surveys and ranked 58 out of 152 competencies as ‘very important/required’, each received 75 % or more of votes. The remaining competencies (N = 94) were included in a list for a further discussion in the focus groups. A Total of fourteen HI experts accepted and joined in the focus groups. The multiphase approach resulted in a competency framework that included 92 competencies, that were grouped into 6 domains and 22 subdomains. The six key domains are: Core Principles; Information and Communication Technology (ICT); Health Sciences; Health Data Analytics; Education and Research; Leadership and Management.

Conclusion: The study developed the Saudi Health Informatics Competency Framework (SHICF) that is based on an iterative, evidence-based approach, with validation from key stakeholders. Future work should continue the validation, review, and development of the framework with continued collaboration from relevant stakeholders representing both the healthcare and educational communities. We anticipate that this work will be expanded and adopted by relative professional and scientific bodies in the Gulf Cooperation Council (GCC) region.

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1. Introduction

With the rapid digital transformation needs of the country, the interest and investment in health information technology by hospitals have been expanded. Demand for Health Informatics (HI) graduates coming from different disciplines (e.g., healthcare professions, Information Technology, etc.) has also increased. Those graduates who want to practice healthcare in Saudi Arabia must obtain their professional classification and registration from the Saudi Commission for Health Specialties (SCFHS) in order to be eligible to work as health informaticians in the Saudi healthcare sector.

The current SCFHS system for licensure and ranking of HI professionals was in need of an update due to the changing landscape of the profession and diversity of the applicants seeking HI licensure. The SCFHS ranking system is now based on the graduate's certification where applicants are placed in one of the four licensure tracks: 'technician' for healthcare practitioners who have a diploma; 'specialist' for healthcare practitioners with a bachelor degree; 'senior specialist' for healthcare practitioners with a master degree; and 'consultant' for healthcare practitioners with PhD or equivalent.

Graduates coming from different disciplines have to be classified within the SCFHS certification-based ranking system which has complicated the process for HI licensure, because of the diversity of the applicants' qualifications. About 2900 had a diploma in medical records management and were classified as health informatics technicians, as listed in the unpublished database of SCFHS in May 2019. Over 700 had master's degrees in HI and bachelor's degrees in different healthcare professions (e.g., Medicine, Pharmacy, Nursing, Dentistry, Public Health, and other Allied Health professionals), and were classified as senior specialists. On the other hand, many practitioners hold post-graduate degrees' in HI but with bachelor's degrees in Information Technology (IT), Information Systems, Computer Science, Business, and Engineering. In this case, there is still uncertainty regarding the inclusion of their bachelor's degrees in the classification; whether to rank them as a senior specialist because they hold master's degrees in HI, or a specialist because they do not hold health-related bachelor's degrees.

Thus, the SCFHS was in need of a licensure system that evaluates whether a candidate has the knowledge and skills required to be certified as a health informatics professional, which is currently missing in Saudi Arabia. To build a certification system, SCFHS established a team of national health informatics experts to develop a competency framework for HI professionals that was Saudi based and can be expanded and utilized in the GCC and the Arab world.

The purpose of this paper is to describe our mixed-methods approach to developing a professional competency framework for health informatics professionals. The proposed *Saudi Health Informatics Competency Framework (SHICF)* identifies the core HI domains, sub-domains, and competencies for health informatics professionals in Saudi Arabia which will satisfy the local workplace needs and the rapid digital transformation in the country.

2. Methods

This research project began in March 2018 was conducted in two phases (Fig. 1). Phase 1 identified the evidence in terms of journal articles and reports pertaining to the HI profession. The literature was reviewed and in turn preliminary domains, sub-domains, and competencies were generated.

The second phase involved the localisation of the generic competency framework to the Saudi context using a multi-methods approach. Details of the methods used in each phase are provided in the following subsections.

2.1. Phase one: identifying preliminary domains, sub-domains and competencies (Scoping review)

Scoping review was conducted in six steps as described in [1] which were: 1) identifying the research question or clear purpose; 2) identifying relevant studies; 3) selecting studies; 4) charting the data; 5) collating, summarizing, and reporting the results; and 6) obtaining consultation.

The question that guided the review was: What competencies are

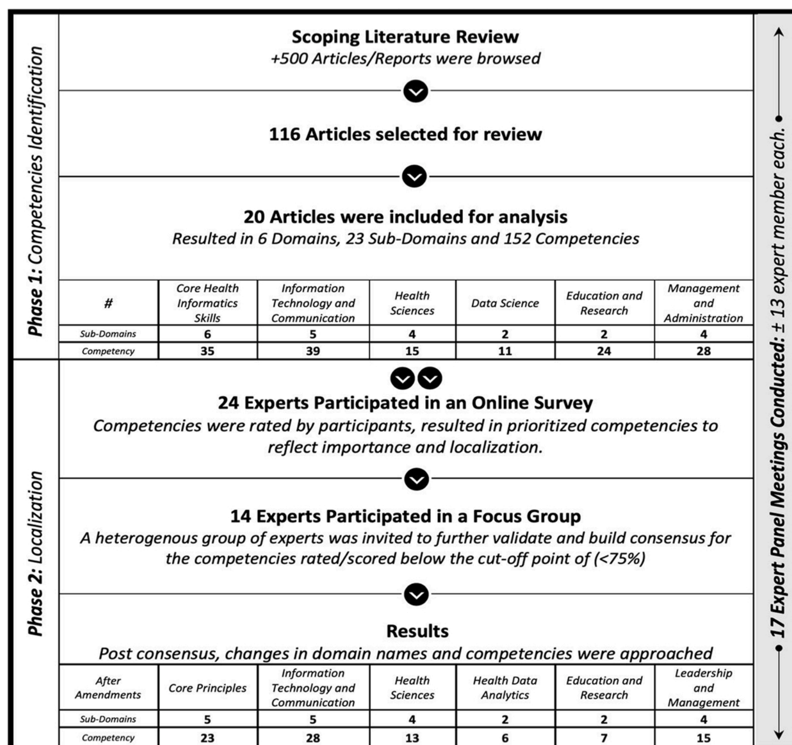

Fig. 1. Summary of the methods used in developing the Saudi Health Informatics Competencies Framework (SHICF).

needed for a HI professional to practice effectively either solo or as a member of a multidisciplinary team? Google scholar was searched using a variety of key search terms such as: health informatics, medical informatics, health informatics competencies, health informatics skills, health informatics competencies framework, health informatics curricula, health informatics education. Any articles or reports that were written in English and aimed at defining or reviewing health informatics competencies were considered eligible for inclusion. No restrictions were made regarding the methodologies of studies or the date of publication. Over 500 articles/reports were initially browsed, and titles, abstracts and keywords were screened by the first author (MA). 116 articles/reports were selected and fully reviewed. As a result of this round of literature review, 20 articles/reports were included in the analysis [2–21]. These studies were then coded in a table by their publication type, origin of publication, title, authors' names, year of publication, and project/research objectives.

Next, for the fifth step, an inductive thematic analysis [22] was performed by two hired-coders screened the included publications to extract and synthesise themes about competencies in the HI field. The two coders were trained for the thematic analysis of the data. The lead author of this work (MA) provided the training for the thematic analysis over a two-week period for both coders. Both coders had previous experience in qualitative coding. The more experienced coder was a PhD graduate (RB) and the second coder (WR) was a Master degree graduate. Both were working within the field of health informatics.

During coding, both coders coded and extracted all papers separately. The content of each paper was examined by looking at the item/ sentences it used to describe competencies and associating terms and synonyms with these themes (e.g., knowledge, skills, attitudes). The extracted items of competencies were reviewed and compared iteratively. Similar competencies were grouped together to create a category or a 'sub-domain'. If a competency did not fit with the previously created category, a new one would be added. The 'sub-domains' were then grouped into overarching domains. The lead author (MA) would review the work and communicate with the coders if there were any major discrepancies in the coding. Once the process was complete, the lead author (MA) reviewed the extracted data and themes generated by the two coders. Any discrepancies were resolved by consensus through multiple meetings with both the coders. The obtained competencies were then restructured and ultimately produced the final list of competencies from this phase.

Findings were shared with the panellists during our meetings at the beginning, midpoint, and final stages of the review, and challenges and uncertainties related to study selection and competencies extraction were discussed. Tables and descriptive analytical methods were used to summarize the review process and results for the experts. Our study selection involved post-hoc inclusion criteria based on the new familiarity with the subject matter and experts' inputs; however, no new search strategy or study selection criteria were added by the panellists in this phase.

2.2. Phase two: Contextualising/localising the health informatics competency framework for Saudi Arabia

2.2.1. Panel meetings

During phase 1 and 2, a total of seventeen experts panel meetings conducted an iterative process of review and revision of the competency framework. Each expert panel was made up of a number of key stakeholders with various backgrounds such as administration, health, IT, and research. Feedback was provided on the development of Saudi Health Informatics Competency Framework.

In each expert panel review, a presentation was made on the status of the competency framework and modifications were made subsequent to each meeting. For example, on May 2, 2018, the primary investigator, provided a review of the framework, compared it to other relevant international frameworks, asked questions on how to localise the framework to the Saudi context, and presented the second study design (the online survey). A list of potential members of the HI community who we think would provide the best information in the online survey was obtained from the panellists. On the expert panel review meeting, which occurred on 10th September 2018, the expert panel provided their final input by making suggested changes to modify the framework to the local context and discussed the outline and methodology of the next study (a focus group) and recommended a list of experts to be invited.

2.2.2. Online survey

Online survey was conducted in August 2018, and purposive sampling was used to recruit participants from healthcare and educational communities working in health informatics within Saudi Arabia [23]. A total of 40 survey participants were identified based on the recommendations from the panellists. Email and SMS were sent to participants for inviting them to the survey. Other characteristics like age, gender, and geographic location were not restricted.

The online questionnaire was built in Survey Monkey™ and comprised a total of 157 questions: 5 demographic questions and 152 competencies-related questions. Completing it took approximately 50−60 min. The first page provided instructions to the participants on how to complete the survey. It provided information about the study title, aims, the participation eligibility criteria, information about the kind of questions that participants would be asked during the survey, how the confidentiality of collected data would be assured, etc. Consent was needed to proceed to the next page in the survey. As this was not a human-subjects project (e.g., no patients or patient information was involved), and it was commissioned by the SCFHS, no ethics board or institutional review board approval was required.

After demographic information was collected, participants were asked to rate competencies generated from the phase one (from 1 to 5, 1 is not important/required whereas 5 is very important/required) based on their perceptions and relation to the Health Informatics profession and Saudi Arabia healthcare workforce. Also, open questions for each competency were provided to allow participants to comment on reasons for assigning a particular rating to the competency.

Raw data from the participants were downloaded from Survey Monkey™ and imported into IBM SPSS where data analysis was conducted. During analysis, the competencies rates, from 1 to 5, were grouped into three categories (not important/required, not sure, and very important/required). A cut-off point was decided to be 75 % to produce a prioritised list of competencies.

2.2.3. Focus group

To further localise the competency framework to Saudi Arabia, a focus group was conducted in October 2018. Purposive sampling was also used to recruit participants based on the recommendations from the panellists [23]. Twenty experts and leaders in the HI field from the healthcare and educational communities were invited to obtain their feedback on the list of competencies generated from the survey analysis. Of those, five participants took part in our survey; however, they were invited to also participate in this study due to their substantial contribution to the HI as a profession or academic career and their involvement in different stages of HI historical timeline in the region. SCFHS contacted each participant via email or SMS to invite them and provide information about the focus group: date, location, start and end times of sessions, and contact information of the facilitators. A response of confirmation was needed in order that the focus group is conducted properly. Fourteen experts confirmed their participation.

The focus group had two sessions, each lasted about 90 min, and one heterogeneous group that was made up of healthcare professionals, academic representatives, industry representatives, healthcare managers, and IT specialists. Mini-demographic survey and consent forms were collected before the sessions started. The first session began with explaining the purpose of the focus group followed by a round of

introductions. During this session, one facilitator (the author MAzi) led the focus group to discuss three domains (Management, Health Sciences, Core HI competencies) whereas the author (MH) took notes of the discussions. In the second session, facilitators swapped their roles. The author (MH) led the discussion of the remaining three domains (ICT, Data Science, Education and research). The lead investigator (the first author) ensured that consensus was achieved upon the point being discussed before moving to the next point in both sessions, answered questions relating to the difference between competencies, and thanked the participants at the end of the session and debriefed with the note takers.

Questions about competencies rating were: Do you agree on this? Should be included/excluded from our list? why? why not? Consensus was needed to be obtained from all the participants for each competency in order to be eligible for inclusion in our list of competencies. The mode of language was preferred to be in Arabic but can be in English or can use a mix of both languages. The facilitators of the focus group were required to have the background and expertise relating to the subject of credentialing and licensure. The facilitator was not allowed to be a person of authority that may intimidate the participants from answering the questions freely or be in direct conflict of interest with the participants such as being their superior. Each facilitator was given a guideline that provides instructions on how to guide the focus group session to ensure consistency. The focus group meetings were not transcribed but rather, the note-taker summarised the main concepts and quotes from competencies. The purpose of this phase acted as a final validation and localisation of the initial draft framework.

3. Results

3.1. Findings from expert panel meetings

Much of the feedback and discussion from the panel focused on four primary issues: planning, methods, execution, and competency framework development in the project. For planning, at the beginning of the project, there was a debate among the panel's members on whether we should adapt an existing competency framework or build a new one. Decision was made to build our own framework for many reasons, see [24]. On methodology, the panel's members would question the type of methods the project team would use to gain insight from participants such as a debate on using the purposive sampling vs the convenience sampling for recruiting participants. Decision was made to use purposive sampling to obtain the best information from HI experts in Saudi Arabia. With regards to the execution of the project, members would recommend including certain participants and exclude others with justified reason. For example, in the focus group session, expert participants with over 11 years of experience were highly preferred.

Expert panel members would also suggest improvements on the language and sentence structure of the competency item. Bloom's Taxonomy [25] was suggested to be used for checking the verbs of competencies and making sure those verbs were consistent with the taxonomy. Also, a recommendation was made to present the *Saudi Health Informatics Competency Framework (SHICF)* at international conferences as a further discussion of the initial draft framework from the perspective of Gulf Cooperation Council (GCC) and international experts. Consequently, the initial draft framework was presented in two international conferences. The first was in France at the MedInfo 2019 Congress that was held on 25–30 August 2019 [24]. The second was in the United Arab Emirates at the GCC eHealth Workforce Development Conference that was held on 2–3 November 2019. This step helped in gaining insights on the various implications of the framework although no major changes were made to the framework, key domains nor competencies as a result of participation in these conferences.

Table 1
Descriptive statistics of the participants in online survey and focus groups.

Item	Online Survey n (%)	Focus Group n (%)
Highest Level of Education		
Bachelors	4 (16.7 %)	3 (21.4 %)
Masters	11 (45.8 %)	3 (21.4 %)
PhD	8 (33.2 %)	6 (42.9 %)
Health/Clinical Fellowship/Residency	1 (4.2 %)	2 (14.3 %)
Specialty / Major		
Health Informatics	13 (54.2 %)	1 (7.1 %)
Health Information Management	1 (4.2 %)	1 (7.1 %)
Information Technology Specialist	6 (25 %)	2 (14.3 %)
Medicine	2 (8.3 %)	4 (28.6 %)
Nursing	1 (4.2 %)	1 (7.1 %)
Pharmacy	1 (4.2 %)	3 (21.4 %)
Other		2 (14.3 %)
Role		
Academic	6 (25 %)	4 (28.6 %)
Administrative	7 (29.1 %)	3 (21.4 %)
Health Informatics Professional	3 (12.5 %)	5 (35.7 %)
Health Professional	2 (8.3 %)	2 (14.3 %)
Information Technology Specialist	5 (20.8 %)	
Other	1 (4.2 %)	
Experience		
1 to 5 years	6 (25.0 %)	1 (7.1 %)
6 to 10 years	8 (33.2 %)	1 (7.1 %)
11 to 15 years	5 (20.8 %)	3 (21.4 %)
More than 16 years	5 (20.8 %)	9 (64.3 %)

3.2. Findings from the scoping review

A total of 13 articles and 7 reports (N = 20) were included in the review [2–21]. Of those twenty publications, 4 came from Canada, 3 from Australia, 1 from New Zealand, 1 from Greece, and the rest from the USA (55 %). Appendix 1 presents the characteristics of the included studies in our review.

During the scoping review, about 1315 competencies related items were initially noted. After iterative reviews and refinements of codes and themes, 6 preliminary health informatics domains and 23 subdomains, and 152 competencies were identified. The preliminary domains identified were: Health Informatics Core Competencies; Information and Communication Technology; Health Sciences; Data Science; Education, Training and Research; Management.

3.3. Findings from online survey

Of the 40 HI professionals invited to participate, 24 participants took part and completed the survey. The majority of the respondents (N = 20, 83 %) hold postgraduate degrees, and 42 % of them had 10 years or more of experience in the HI field. For speciality, 54 % of participants were specialised in HI, 25 % in IT, and the rest was specialised in health information management (HIM), medicine, nursing, and pharmacy. In terms of participants' roles and duties, six participants (29 %) worked in administrative related positions such as Chief Health Information officer, 25 % worked as faculty members in public universities, 21 % as IT specialists, 12 % as Health Informaticians, and 8 % as healthcare professionals. Table 1 presents all the descriptive statistics of our participants.

Of 152 competencies, a total number of 58 were rated 'very important/required' and received 75 % or more of votes. If a competency was rated 'very important/required' by the majority of the participants (N>= 18, 75 %), it was considered eligible for inclusion in the prioritised list. The remaining competencies (N = 94) that received less than 75 % of the votes in our online survey were to be included in a list of competencies that need to be further discussed in the following study (focus group).

For open answers, the majority were only supporting such as "This is highly needed in practice", or giving examples for the provided domain

Table 2
Selected examples of amendments made in the domain, sub-domains, and competencies levels.

Level of Change Before Amendments	Domain After Amendments	Reason
Management	Title changed to 'Leadership and Management'	'Leadership' sub-domain is added to this domain
Data Science	Title changed to 'Health Data Analytics'	To be focused on the health field
Core Health Informatics Competencies	Title changed to 'Core Principles'	To be clearly distinguished from other competencies
Education, Training and Research	Title changed to 'Education and Research'	Competencies related to 'Training' is included in the sub-domain 'IT Support, Maintenance and Upgrade Process'
Level of Change	**Sub-domain**	
Strategic Planning and Risk Management	Strategic Planning	Risk Management is included in the sub-domain 'Project & Change Management' and hence removed from here
Areas of Specialisations in Health Informatics	Omitted	Corresponding competencies were merged with ones in the sub-domain 'Basic Theories and Concepts in Health Informatics'.
Resources Management	Omitted	Corresponding competencies were merged with ones in the sub-domain 'Project & Change Management'.
Level of Change	**Competency**	
Not Exist	Added a new one	The competency "Organise tasks related to data retrieval and management from business side to serve research publications and/or reporting of data." is added to the sub-domain 'Research'.
Not Exist	Added a new one	The competency "Understand and apply the principles of the development and delivery of end user training that are necessary for a successful system implementation and upgrading" is added to the sub-domain 'IT Support, Maintenance and Upgrade Process'.
Demonstrate how file organisation and storage methods (e.g., Hash, Heap and ISAM) determine the access, efficiency, flexibility of devices.	Omitted	Too specific/technical
Aid in construction of an informatics vision that coordinates with the enterprise strategic plan.	Paraphrased (or changes in wordings) to: Understand the contribution of Health Informatics role, tools and initiatives in aiding healthcare strategic plans.	To be compatible with Bloom's Taxonomy
Ensure that documentation in the health record reflects timeliness, completeness, accuracy, appropriateness, quality, integrity, and authenticity as required.	Paraphrased (or changes in wordings) to: Ensure that documentation in the health record reflects timeliness, completeness, accuracy, appropriateness, quality, integrity, and authenticity as required, and compliance with national regulations and international standards.	To make it complete, these words is added "and compliance with national regulations and international standards"
• Follow best practices and enterprise policies for developing a request for proposal (RFP). • Identify and engage different stakeholders to incorporate their expertise in project planning and decision making. • Understand and analyse users and stakeholders' requirements about the project. • Manage and monitor project performance according to the scope, schedule, budget and risk management plans.	Merged with other competencies	Those competencies were considered relevant and hence combined into one: Understand Project Management best practices, relating to the following: a Project Integration Management. b Project Scope Management. c Project Time Management. d Project Human Resources Management. e Project Cost Management. f Project Quality Management. g Project Communication Management. h Project Risk Management. i Project Procurement Management.

or competencies such as "This is very important for the success of implementing an IT project". Two participants suggested changing the domain name of 'Data Sciences' to 'Health Data Analytics'.

3.4. *Findings from the Focus Group*

Of the 20 HI professionals invited to participate, 8 males and 6 females (N = 14) accepted and joined. The majority of the participants (N = 12, 86 %) reported having more than 11 years of experience in practice, and (N = 11, 79 %) participants hold postgraduate degrees. About 50 % of participants were specialised in medicine and pharmacy, 14 % in IT, and the rest was specialised in HI, HIM, and nursing. Table 1 presents the descriptive statistics of our participants in the focus group.

Consensus was obtained from all the participants for each competency in order to be eligible for inclusion in our final list of competencies. This led to verifying all the health informatics domains (6 out of 6), 21 sub-domains out of 23, and 92 competencies out of 152. A new sub-domain 'leadership' was added to the domain 'Leadership and Management' whereas the sub-domain 'Resource Management' was deleted due to its inclusion and merged with 'Project & Change Management' sub-domain. Similarly, the sub-domain 'Areas of Specialisations in Health Informatics' was deleted and corresponding competencies were merged with ones in the sub-domain 'Basic Theories and Concepts in Health Informatics'. As two sub-domains were deleted and a new one was added, the total of all sub-domains in our framework became 22.

In addition, the focus group consensus resulted in a number of amendments to the domain or sub-domain's title. For example, four domains' names were refined based on consensus obtained from experts participating in the workshop. In phase one, the names of these domains were: Health Informatics Core Skills; Data Science; Education, Training and Research; and Management which then retitled to Core Principles; Health Data Analytics; Education and Research; and Leadership and Management respectively. Table 1 presents the amendments made at the domain and sub-domains level.

Furthermore, at the competencies level, various and mixed actions

Fig. 2. The Saudi Health Informatics Competency Framework (SHICF) version 1.0.

were also taken to treat competencies obtained from the online survey. These actions and amendments were: keep it; re-include; omit; merge with other competencies; shift to another place; paraphrase; and add a new one. For instance, competencies related to training were shifted from the domain 'Education and Research' to the sub-domain 'IT Support, Maintenance and Upgrade Process' because these competencies were considered to be mostly applied in the cases of new employees, using a new health information system or maintaining it. Table 2 illustrates more examples of these amendments.

4. Discussion

The multiphase approach led to developing the Saudi Health Informatics Competency Framework version 1.0. This section discusses our competency framework and presents its applications in the SCFHS evaluation, HI profession, and HI education.

4.1. The Saudi Health Informatics Competency Framework (SHICF) Version 1.0

Our competency framework includes ninety-two competencies that are grouped into six key domains and twenty-two sub-domains. Fig. 2 presents the key six domains which are: Core Principles; Information and Communication Technology; Health Sciences; Health Data Analytics; Education and Research; Leadership and Management. These domains are described by summarizing the content and keywords of sub-domains and competencies as follows:

1 Core Principles refers to health informatics theoretical foundations, standards and interoperability, applications (e.g., EHR, order entry, registries, decision support systems, clinical data documentation and management tools and methods, etc.), and practice including legal, ethical, and social aspects of health.
2 Information and Communication Technology refers to basic computer literacy, information technology concepts, components, methods, and tools for systems design and testing including standards, integration, protection of information, and training end-users.
3 Health Sciences refers to understanding and improving medical/clinical practice, basic health science concepts and terminologies, healthcare systems and related policy and regulations.
4 Education and Research refers to the array of education and research concepts, methods, tools for teaching and conducting studies including the use of appropriate communication and language to represent information and convey results to the audience.

Table 3
Summary of the total competencies per domains.

Domain	Total per domain (Scoping Review)	Very important /required* (Online Survey)	Consensus (Focus Group)	%
Core Principles	35	20	23	66 %
ICT	39	14	28	72 %
Health Sciences	15	3	13	87 %
Health Data Analytics	11	0	6	55 %
Education and Research	24	4	7	29 %
Leadership and Management	28	17	15	54 %
Total	**152**	**58**	**92**	61 %

* a cut-off point was decided to be 75 % for a competency to be eligible for inclusion as very important/required.

5 Health Data Analytics refers to methods, processes, and tools for collecting, integrating, representing, sharing, and using health data (in various forms) to extract knowledge and insights by using data analysis and statistical knowledge.
6 Leadership and Management refers to the concepts and methods of project and change management, quality principles, establishing and accomplishing goals, business practices and organisational strategy at all levels.

Each key domain has a range of two to five sub-domains. The domain 'Core Principles' has five sub-domains and twenty-three competencies. The domain 'Information and Communication Technology' has also five sub-domains and twenty-eight competencies. The domain 'Health Sciences' has four sub-domains and thirteen competencies. The domain 'Health Data Analytics' has two sub-domains and six competencies. The domain 'Education and Research' has two sub-domains and seven competencies. The domain 'Leadership and Management' has four sub-domains and fifteen competencies. Appendix 2 presents all the sub-domains and corresponding competencies.

Each sub-domain has a range of six to twenty-eight competencies. The ICT domain involves the highest number of competencies (N = 28), and this is consistent with well-known competency frameworks such as the one from Digital Health Canada that was formerly known as COACH [26], and the competency framework from CHIA (Certified Health Informatician Australasia) [5]. COACH has 18 competencies in the information sciences domain which is composed of IT and information management, and this represents over two-thirds of competencies in the framework. In CHIA, the ICT and information science domains together include 25 % of the total competencies whereas the rest 75 % belong to the core HI competencies, health and biomedical science, management, and human and social context domain.

The Health Data Analytics domain, on the other hand, involves the lowest number of competencies (N = 6). However, we believe that at the time of conducting our focus group, it was not seen as important as it is now. There is an incremental increase in the interests in gaining skills related to data collection from wireless medical devices, Internet of Things (IoT), data integration on real-time, and utilization of artificial intelligence (AI) in EHR or clinical patient monitoring apps [27]. In addition, a recent study from IMIA that was led by Douglas Fridsma [28] resulted in developing HI domains of practice, and one of the key domains was: 'Data Governance, Management, and Analytics'. Recent cross-industry estimates that demands for data scientists within the HI field will continue to grow rapidly [29].

About 61 % (N = 92) of competencies in the final list of the Saudi Health Informatics Competency Framework version 1.0 are in alignment

Summary table

What was already known on the topic

- The current system for licensure and ranking of HI professionals was in need of an update due to the changing landscape of the profession and diversity of the applicants seeking HI licensure, especially in Saudi Arabia.
- A local system that evaluates whether a candidate has the knowledge and skills required to be certified as a health informatics professional is required.

What this study added to our knowledge

- This work will provide valuable benefits to the regulation body in supporting planning activities for health informatics professional classification, especially in Saudi Arabia.
- The methodology that was followed in this study is unprecedented for Saudi Arabia and illustrates the challenges involved in developing a framework given the local workforce needs, country's vision of healthcare digitization, the multidisciplinary nature of this field, discord between Saudi classification rankings and international ranks for HI professionals.
- The study developed the first version of the *Saudi Health Informatics Competency Framework (SHICF)* that is based on an iterative, evidence-based approach, with validation from key stakeholders.
- The framework can be also utilized to by scientific and professional associations of interest to the field, and help in establishing clear career pathways, and improving consistency of academic programs that deliver HI education.

with competencies identified from the scoping review. Highest alignment occurred in the 'Health Sciences' domain as 87 % are included; the 'ICT' domain comes next with 72 % inclusion of competencies, and then the 'Core Principles' domain with 66 %. More than half of those competencies are included in the 'Health Data Analytics' domain (55 %) and 'Leadership and Management' domain (54 %). In the 'Education and Research' domain, only 7 out of 24 (29 %) are included in our final list; and the cause of this low percentage is due to shifting competencies related to training to a sub-domain in the ICT domain based on a consensus obtained from our participants in the focus group as mentioned in the previous section. Table 3 provides a summary of the total competencies per domains as identified from the scoping review, online survey and focus group.

4.2. Implications of the SHICF framework

The competency framework included in this work provides valuable guidance and needed consistency to the SCFHS evaluation team when credentialing and evaluating HI professionals in the short term. The SCFHS currently interviews candidates without providing the interviewer or interviewee with specific areas of study, leading to a very subjective interview process. Providing the interviewer and interviewee with the competency framework which shows the core HI domains, subdomains, and competencies that are needed to perform as a health informatics professional in Saudi Arabia, would help guide both the interviewer and interviewee.

The outcomes of a more objective examination using the proposed competency framework could be reviewed, evaluated, modified by the SCFHS. This recommendation should only be used in the short-term, 6–12 months post implementation, and a more objective and validated exam should be developed in incremental stages. For example, in future phases, the SCFHS could add open ended written questions in addition to the interview questions. Also, as the competency framework is tested and becomes more valid, MCQ exams can be introduced into the evaluation process of HI professionals. A team of HI experts should work on developing, monitoring, and evaluating the examination of HI professionals using the competency framework introduced in this paper.

The initial Saudi Health Informatics Competency Framework (SHICF) proposed in this work can also be utilised to define the field of health informatics within the country. SCFHS can use the initial SHICF framework to define the boundaries of the field of health informatics and distinguish it from areas such as Bioinformatics and Health Information Management based on the competencies outlined in the framework. As a result, SHICF will provide a clearer definition and formal recognition of the HI field as it is practiced within the country.

Finally, the initial competency framework can be utilised to refine the HI academic programs of local educational institutions. Since we have developed an initial framework, the framework itself may not be reflective of what is being taught today in HI programs across the country. Our efforts were focused on developing an ideal preliminary competency framework that would ensure that Saudi HI graduates are capable to compete and excel locally, regionally, and internationally. Although lofty are the goals of the work, a more pragmatic approach in the short-term would require input from current university programs to be refined based on further validate the competency framework, and specifically, the competencies for each sub-domain.

4.3. Limitations of the study

Our study has its own limitations. Our thematic analysis mainly concerned with the extracted data on the competencies pertaining to HI profession. The limited data extracted from the included publications were not sufficient to provide a standardized definition of our key domains or conduct any comparison of our definitions that were presented in this paper with the relevant ones in the included publications. For this reason, a larger consensus needs to be created to overcome this limitation. The framework and list of domains and sub-domains will be publicly available for comments which it is anticipated to help in refining and/or updating the current version.

5. Conclusions

In conclusion, we believe that this initial work will provide valuable benefits to the SCFHS in supporting planning activities for health informatics professional classification within the Kingdom of Saudi Arabia. The methodology that was followed in this study is unprecedented for Saudi Arabia and illustrates the challenges involved in developing a framework given the local workforce needs, country's vision of healthcare digitization, the multidisciplinary nature of this field, discord between Saudi classification rankings and international ranks for HI professionals.

The field continues to evolve and the SCFHS needs to continually review the proposed competency framework along with local universities to develop a more contextual based HI competency framework that

would make HI professionals competitive, competent, and reliable professionals helping improve overall healthcare quality within Saudi Arabia. This framework can be extended to the rest of the Arab world via the Middle East North Africa Health Informatics Association (MENA-HIA) or other scientific and professional associations of interest to the field, and help in establishing clear career pathways, and improving consistency of academic programs that deliver HI education.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix 1 Characteristics of the Included Studies in our Scoping Review

Nature of Publication	Title of Publication	Author Name	Origin of Publication	Year of Publication	Project/Research Objectives
Report	Pointing the way: competencies and curricula in health informatics applied health informatics	Dominic Covvey, David Zitner, & Robert Bernstein	Canada	2001	To describe the work, we have done related to the specification of the required AHI skills, knowledge, and experience, and the development of a curriculum in Applied Health Informatics.
Article	A survey of academic and industry professionals regarding the preferred skillset of graduates of medical informatics programs	Stefan Hoffmann, & Joan Ash	US	2001	To describe the skills needed by informatics master's degree graduates so that students will know what is desired in the workplace, and curriculum designers can assure that courses cover relevant areas.
Article	Australian health informatics educational framework	Sebastian Garde, & Evelyn Hovenga	Australia	2004	To provide guidance with regard to 'good' Health Informatics education (to develop associated competencies and their degree) while acknowledging the diversity of different roles in Health Informatics, the diversity of ways that lead to Health Informatics, and the diversity of education within the Health Informatics discipline.
Article	WebSAT: a web-based competency self-assessment system linking to educational resources	Dominic Covvey, Shirley Fenton, Doug Mulholland, & K Young	Canada	2006	To describe a web-based system that enables an individual to assess him/her self against the set of competencies required for a variety of roles in the area of Applied Health Informatics (AHI).
Article	Building health informatics skills for health professionals: results from the Australian health informatics skill needs survey	Sebastian Garde, David Harrison, Mohammed Huque, & Evelyn JS Hovenga	Australia	2006	To ascertain health professionals' perceptions of health informatics skills required in their roles.
Article	Competencies for graduate curricula in health, medical and biomedical informatics	Qi Rong Huang	Australia	2007	To investigate the recommended competencies for health and medical informatics, aiming to develop a framework for use in curricular development.
Report	Health information management and informatics core competencies for individuals working with electronic health records EHR	Joint Workforce Task Force by American Medical Informatics Association (AMIA) and the American Health Information Management Association (AHIMA)	US	2008	To define basic competencies for those who use EHRs in their daily work.
Report	Competencies for public health informaticians	Centers for Disease Control and Prevention, & University of Washington's Center for Public Health Informatics	US	2009	To define informatics competencies for the general public health.
Article	Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics – First Revision	John Mantas, Elske Ammenwerth, George Demiris, et al.	Greece	2010	To revise the existing international recommendations in health informatics/ medical informatics education that help in investigating the educational needs for health care professionals to acquire knowledge and skills in information processing and ICT.
Article	A curricula-based comparison of biomedical and health informatics programs in the USA	Julia Kampov-Polevoi, Bradley M, & Hemminger	US	2011	To develop a scheme for systematic comparison of programs across the entire BMHI spectrum and to identify commonalities among informatics curricula that were guided by published competency sets.
Article	AMIA Board white paper: definition of biomedical informatics and specification of core competencies for graduate education in the discipline	Casimir Kulikowski, Edward Shortliffe, Leanne Currie, et al.	US	2012	To highlight the central shared set of competencies that should guide curriculum design and that graduate students should be expected to master.

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Nature of Publication	Title of Publication	Author Name	Origin of Publication	Year of Publication	Project/Research Objectives
Report	Health informatics professional core competencies	CoACH: Canada's Health Informatics Association	Canada	2012	To set out a common core or shared set of skills, knowledge, attitudes, and capabilities necessary to effectively perform as a HI professional.
Article	Competencies for global health informatics education: leveraging the US experience	Kendall Cortelyou-Ward, Alice Noblin, & Summerpal Kahlon	US	2013	To address the changing nature of the profession and develop core competencies for a global HIT economy.
Article	Gap analysis of biomedical informatics graduate education competencies	Anna Ritko, & Michelle Odlum	US	2013	To define gaps between competencies and curricula.
Article	Building an educated health informatics workforce – the New Zealand experience	David Tudor Parry, Inga M Hunter, Michelle Honey, et al.	New Zealand	2013	To improve IT use in healthcare by trained clinicians, management and technical workforce.
Report	The Australian Health Informatics Competencies Framework and Its Role in the Certified Health Informatician Australasia (CHIA) Program	Fernando Martin-Sanchez, David Rowlands, Louise Schaper, & David Hansen	Australia	2013	To test whether a candidate has the knowledge and skills that are identified in the competencies framework to perform as a health informatics professional.
Article	Convergent evolution of health information management and health informatics	C. J. Gibson, B.E. Dixon, & K. Abrams	US	2015	To compare the current domains and competencies, review the characteristics as well as the education and credentialing of HIM and HI.
Article	A review of biomedical and health informatics education: A workforce training framework	Saif Khairat, Ryan Sandefer, David Marc, & Lee Pyles	US	2016	To review the current state of health IT training programs (core components of the curricular competencies) and identify limitations in workforce expectations and student/trainee level of preparedness.
Report	AMIA Accreditation Committee	AMIA & CAHIIM	US	2016	To define knowledge, skills, and attitudes necessary to succeed as a graduate from an applied master of science in health informatics program.
Report	Applied public health informatics competency model	the Public Health Informatics Institute (PHII)	US	2016	To frame the knowledge, skills, and abilities that public health practitioners need to address the informatics challenges at their agencies.

Appendix 2 Final Key Domains, Sub-Domains, and Competencies in the Saudi Health Informatics Competency Framework Version 1.0

The framework is also available online at https://www.shicf.online/ (This is a beta version tool).

1. Core Principles in Health Informatics
1.1. Basic Theories and Concepts in Health Informatics
1.1.1. Demonstrate an understanding of digital health concepts including Telehealth, Telemedicine, M-health, Consumer Health Informatics, Virtual Reality, Cyber Security, etc.
1.1.2. Apply knowledge of basic clinical/medical and biomedical informatics theories, principles and concepts.
1.2. Health Information Standards and Interoperability
1.2.1. Demonstrate an understanding of health informatics standards and their appropriate use (e.g., classifications, vocabularies, nomenclature, etc.), and interoperability.
1.2.2. Support adoption of upgrades in standards for all data sources when changes in standard specifications or versions make this necessary.
1.3. Health Information Systems
1.3.1. Identify different information systems used in health care (EHR, Decision Support Systems / Knowledge Based Systems / Expert Systems, Self/Remote-monitoring devices and Apps in healthcare, biomedical imaging and signal processing), their basic functions, use, and the general characteristics and architecture.
1.3.2. Apply good practice to the adoption and realisation of clinical value of information systems (e.g., Inpatient Electronic Medical Record (EMR), Computerised Provider Order Entry (CPOE) systems, Emergency Department Information System (EDIS), etc.
1.3.3. Demonstrate an understanding of different applications of information systems to patient management, acquisition, representation and engineering of medical knowledge.
1.3.4. Demonstrate an understanding of the data interrelationships and dependencies among the various health information systems (e.g., EHR, order entry, registries, decision support systems, etc.)
1.3.5. Support data integrity and validity within information system, and quality principles and methods across the information system's life cycle (e.g., requirement specification, analysis, implementation, risk management and user training).
1.3.6. Define an appropriate practice to ensure that information system is aligned with clinical goals.
1.3.7. Apply good practice to the governance of the information system.
1.3.8. Identify evaluation frameworks for health information systems that address cost-effectiveness, data quality, conformance to requirements, scalability and ability to meet medical/clinical objectives.
1.3.9. Support the use of health information systems (e.g., EHR, order entry, registries, biomedical imaging and signal processing systems such as PACS, decision support systems, etc.) by clinicians and other staff.

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1.3.10. Support information systems for public health use (including environmental risks) using public health and environmental health information, and supply environmental agencies with public health information for public policy development.
1.4. Clinical Data Documentation and Management
1.4.1. Identify commonly used formats, structures, attributes, types of data collected in healthcare, and their use (such as individual, comparative reports, and trended data), and methods for recording and communication of clinical data (e.g., paper-based, electronic medical records).
1.4.2. Ensure that documentation in the health record reflects timeliness, completeness, accuracy, appropriateness, quality, integrity, and authenticity as required, and compliance with national regulations and international standards.
1.4.3. Define appropriate methods to correct errors entered in electronic health records.
1.4.4. Apply appropriate documentation and health data management practice including the ability to use medical/clinical coding and classification systems (e.g., ICD, ICF, ICHI), construction and maintenance of medical coding.
1.4.5. Make use of data quality principles and methodologies in the identification, use and management of information sources (people and systems).
1.5. Legal, Ethical, and Social Aspects of Health Informatics
1.5.1. Demonstrate knowledge of legal, ethical principles and values of the discipline, for example, human subjects, informed consent, secondary use of data, confidentiality, de-identification methods when necessary to protect personal privacy, Code of Ethics.
1.5.2. Support legal, ethical principles and values of the discipline including local privacy laws, rules, and regulations.
1.5.3. Demonstrate an understanding of the role and responsibility of informatician to the profession.
1.5.4. Define and discuss ethical and security issues including accountability of health care providers and managers and health specialists and the confidentiality, privacy and security of patient data, and protection of patients' electronic health information.
2. Information and Communication Technology
2.1. Basic Computer Literacy
2.1.1. Make use of basic word processing and spreadsheet (e.g., create, edit, format document using tables and graphs), database (e.g., collect, manage and disseminate information), desktop presentation applications, and different software to generate reports as applicable to the required work.
2.1.2. Identify, evaluate and use web-based health information resources, and Internet resources.
2.1.3. Demonstrate basic computer operating procedures (e.g., login and logoff, use icons, windows operating systems and menus).
2.1.4. Demonstrate proficiency in the operating environment (Windows, Mac), and performing multitasking (open and work with more than one application at a time).
2.1.5. Conduct basic file and folders operations (e.g., open, create, delete, rename, save, copy, and print a file).
2.1.6. Use a Web browsing application, and search engines to find health related information.
2.1.7. Demonstrate how to use email, address, forward, send attachments, and netiquette.
2.1.8. Apply basic computer concepts and terminology in order to use computers and peripheral devices, computer communications systems (store, retrieve, transmit, and manipulate data).
2.1.9. Resolve minor technical problems associated with use of computers.
2.2. Basic Concepts and Components of Information Technology
2.2.1. Describe the basic concepts of relational databases (e.g., design, structure, functions, DBMS architecture, database languages).
2.2.2. Illustrate how data structures, algorithms, flowcharts and programming solve problems related to system design.
2.2.3. Understand and apply methods of inquiry and criteria for selecting best algorithms.
2.2.4. Apply algorithms, techniques, and methods to solve problems.
2.3. Systems Design and Testing
2.3.1. Identify user needs and translate them into systems design.
2.3.2. Apply informatics/computer science theory and human factors to design and implement information systems.
2.3.3. Apply the framework of the software development life cycle (SDLC) to shape planning, analysis, design, execution and maintenance of software development.
2.3.4. Motivate relevant stakeholders and users at the appropriate stages of the system development life cycle.
2.3.5. Support information systems policies and procedures as required by national health information initiatives from national, local, and organisational levels.
2.3.6. Apply quality principles and methods on the system's development life cycle (e.g., requirement specification, analysis, design implementation, and user training).
2.3.7. Support seeking feedback from users and stakeholders of information systems in programs or projects.
2.4. Information System Security
2.4.1. Identify data and information misuse and security issues.
2.4.2. Distinguish risks related to information systems and applications including security (confidentiality, integrity, availability).
2.4.3. Explain how to document the physical protection of public health information systems.
2.4.4. Create a good set of information security metrics and policies.
2.5. IT Support, Maintenance and Upgrade Process
2.5.1. Ensure user support and technical assistance is provided when it is needed with the time sensitivity of information system (i.e., prioritised appropriately).
2.5.2. Support availability of systems and applications around a clock like 24 hours/day, 7 days/week, when necessary to support the project or program.
2.5.3. Apply business continuity principles (e.g., backup and recovery strategies in case of system failure).
2.5.4. Understand and apply the principles of the development and delivery of end user training that are necessary for a successful system implementation and upgrading.
3. Health Sciences
3.1. Basic Clinical/Medical Knowledge
3.1.1. Describe the main concepts of human body structures and functions and the different levels of biological organisation such as (molecule, cell, tissue, organ, system).
3.1.2. Demonstrate an understanding of the main concepts of biosciences (anatomy, physiology, microbiology, genomics), and clinical disciplines such as internal medicine, surgery, etc.).
3.1.3. Demonstrate knowledge of the main principles and process of clinical diagnostic and therapeutic strategies.

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3.1.4. Identify and assess the basic determinants related to health.
3.1.5. Identify and measure clinical outcomes.
3.1.6. Understand principles of evidence-based practice.
3.2. Medical Terminology
3.2.1. Understand basic clinical terminology and commonly used abbreviations and acronyms.
3.2.2. Describe and analyse the various parts of a medical terms, word root, prefixes suffixes that make a medical terminology, and general anatomical features.
3.3. Healthcare Systems
3.3.1. Demonstrate an understanding of different types of national and international healthcare delivery models (e.g., hospitals, clinics, ambulatory centres and community health centres, regional health authorities) and their interrelationships.
3.3.2. Demonstrate knowledge of the assessment of health facilities (e.g., hospitals, clinics) performance and report on the efficiency and resource use of such facilities (e.g., hospitals beds, admission/discharge/death rate, workload, etc).
3.3.3. Explain how continuity of care, shared care, Saudi medical insurance and other models of care are essential for inter-organisational relationships and the overall health care system.
3.4. Health-Related Policy and Regulations
3.4.1. Demonstrate an understanding of relevant Saudi health policy, including laws, regulations, regulatory compliance, advocacy, national, and regional.
3.4.2. Contribute to development of operational policies, processes for changing policies, and policies and procedures related to health data and information.
4. Health Data Analytics
4.1. Quantitative Analysis
4.1.1. Use statistical analysis packages.
4.1.2. Demonstrate the knowledge of discrete mathematics, descriptive analysis of health data (means, medians, significance), Linear Algebra, multivariable Calculus, etc.
4.1.3. Explain the concepts of inferential statistics, probability, distributions, and statistical tests within the clinical uses.
4.2. Knowledge Management and Representation
4.2.1. Demonstrate an understanding of the key attributes of data and information (e.g., quality, integrity, accuracy timeliness, appropriateness) and their limitations within use (e.g., clinical and analytical uses).
4.2.2. Identify the difference between data and information; and incorrect data and how to take corrective action.
4.2.3. Apply basic analytical and visualisation methods for data wrangling, knowledge discovery and representation of health information.
5. Education and Research
5.1. Education
5.1.1. Use informatics to support research and improve information literacy.
5.1.2. Demonstrate knowledge of informatics concepts and methods to support effective solutions for clinical, research and education needs.
5.1.3. Describe public health, health promotion and the role of information to support them (biometry, epidemiology) as well as to enable health research.
5.2. Research
5.2.1. Demonstrate an understanding of basic research concepts and methods.
5.2.2. Relate the common conceptual frameworks that are used in health informatics to specific problems.
5.2.3. Use appropriate communication and language to represent information and convey results to audience.
5.2.4. Organise tasks related to data retrieval and management from business side to serve research publications and/or reporting of data.
6. Leadership and Management
6.1. Project & Change Management
6.1.1. Understand and apply Project Management principles (e.g., operating framework, life cycle, budgets, resources, timelines, milestones, monitoring, status reports, etc.).
6.1.2. Understand Project Management best practices, relating to the following:
a Project Integration Management.
b Project Scope Management.
c Project Time Management.
d Project Human Resources Management.
e Project Cost Management.
f Project Quality Management.
g Project Communication Management.
h Project Risk Management.
i Project Procurement Management.
6.1.3. Construct and utilise any necessary changes to the project planning, teams, resources, collaboration, motivation, conflict resolution and business cases.
6.1.4. Ability to contribute to project action plan, promptly identifying and acting on deviations from the plan or budget, and advising key stakeholders.
6.2. Quality Management
6.2.1. Demonstrate knowledge of the importance of quality practices and patient safety in healthcare.
6.2.2. Demonstrate an understanding of various quality improvement models; tools including quality planning and assurance and control; factors or indicators related to structure, process and outcome.
6.2.3. Conduct continuous quality improvement by using iterative performance measurement and quality metrics, analysis, and design changes.
6.2.4. Apply best practices in quality improvement and process engineering to facilitate business and clinical transformation.
6.3. Strategic Planning
6.3.1. Understand the contribution of Health Informatics role, tools and initiatives in aiding healthcare strategic plans.
6.3.2. Apply the basic theories, concepts and practices of management including: organisational behaviour and management.
6.3.3. Apply concepts of business process and workflow mapping, process design/redesign that coordinate with the enterprise strategic plan, and incorporating input from staff.

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6.4. Leadership
6.4.1. Demonstrate appropriate leadership skills, such as communication, motivation, creativity, feedback and responsibility.
6.4.2. Demonstrate problem-solving techniques, conflict management, interpersonal skills, team development and strategic thinking skills, and delineate responsibilities for team members.
6.4.3. Perceive the importance of mutual respect and shared values, as well as one's own role, the role of other professions and stakeholders, and the role of teamwork and team science to solve complex health and health information problems.
6.4.4. Identify teamwork in health care, the practice of communication to expand the traditional roles of health workers and to make decisions.

Appendix 3 Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijmedinf.2020.104362.

References

[1] H.L. Colquhoun, D. Levac, K.K. O'Brien, S. Straus, A.C. Tricco, L. Perrier, et al., Scoping reviews: time for clarity in definition, methods, and reporting, J. Clin. Epidemiol. 67 (12) (2014) 1291–1294, https://doi.org/10.1016/j.jclinepi.2014.03.013.

[2] J. Mantas, E. Ammenwerth, G. Demiris, et al., Recommendations of the International Medical Informatics Association (IMIA) on education in biomedical and health informatics first revision, Methods Inf. Med. 49 (2010) 105–120.

[3] C.A. Kulikowski, E.H. Shortliffe, L.M. Currie, et al., AMIA Board white paper: definition of biomedical informatics and specification of core competencies for graduate education in the discipline, J. Am. Med. Inf. Assoc. JAMIA 19 (2012) 931–938.

[4] Digital Health Canada, formerly known as COACH, Health Informatics Professional Core Competencies, 2018 https://digitalhealthcanada.com/wp-content/uploads/2017/03/Health-Informatics-Core-Competencies.pdf (accessed 18 May 2018).

[5] F. Martin-Sanchez, D. Rowlands, L. Schaper, D. Hansen, The Australian health informatics competencies framework and its role in the Certified Health Informatician Australasia (CHIA) Program, Stud. Health Technol. Inform. 245 (2017) 783–787.

[6] AMIA Accreditation Committee. https://www.amia.org/sites/default/files/AMIA-Health-Informatics-Core-Competencies-for-CAHIIM.PDF (accessed 25 Feb 2018).

[7] S. Khairat, R. Sandefer, D. Marc, L. Pyles, A review of biomedical and health informatics education: a workforce training framework, J. Hosp. Adm. 5 (2016) 10.

[8] H.D. Covvey, S. Fenton, D. Mulholland, K. Young, Pointing the Way: Competencies and Curricula in Health Informatics Applied Health Informatics, 2018 (accessed 25 Feb 2018), http://www.nihi.ca/nihi/ir/Pointing%20the%20Way%20MASTER%20Document%20Version%201%20Final.pdf.

[9] H.D. Covvey, S. Fenton, D. Mulholland, K. Young, WebSAT: A web-based competency self-assessment system linking to educational resources, AMIA Annu. Symp. Proc. 2006 (2006) 171–174.

[10] J. Kampov-Polevoi, B.M. Hemminger, A curricula-based comparison of biomedical and health informatics programs in the USA, J. Am. Med. Inform. Assoc. 18 (2011) 195–202.

[11] S. Hoffmann, J. Ash, A survey of academic and industry professionals regarding the preferred skill set of graduates of medical informatics programs, Stud. Health Technol. Inform. 10 (2001) 1028–1032.

[12] Q.R. Huang, Competencies for graduate curricula in health, medical and biomedical informatics: a framework, Health Informatics J. 13 (2007) 89–103.

[13] C.J. Gibson, B.E. Dixon, K. Abrams, Convergent evolution of health information management and health informatics: a perspective on the future of information professionals in health care, Appl. Clin. Inform. 6 (2015) 163–184.

[14] K. Cortelyou-Ward, S. Kahlon, A. Noblin, Competencies for global health informatics education: leveraging the US experience, Educational Perspectives in Health Informatics and Information Management (2013).

[15] A.L. Ritko, M. Odlum, Gap analysis of biomedical informatics graduate education competencies, AMIA Annu. Symp. Proc. 2013 (2013) 1214–1223.

[16] D. Parry, I. Hunter, M. Honey, et al., Building an educated health informatics workforce: the New Zealand experience, Stud. Health Technol. Inform. 188 (2013) 86–90.

[17] S. Garde, D. Harrison, M. Huque, E.J. Hovenga, Building health informatics skills for health professionals: results from the Australian Health Informatics skill needs survey, Aust. Health Rev. 30 (2006) 34–45.

[18] The Public Health Informatics Institute, Applied Public Health Informatics Competency Model, 2018 (accessed 18 May 2018), http://www.phii.org/resources/view/9462/applied-public-health-informatics-competency-model.

[19] Public Health Informatics Competencies Working Group, Competencies for Public Health Informaticians, 2018 (accessed 18 May 2018), https://www.cdc.gov/informaticscompetencies/pdfs/phi-competencies.pdf.

[20] Joint Workforce Task Group, Health Information Management and Informatics Core Competencies for Individuals Working With Electronic Health Records, 2018 (accessed 20 May 2018), https://www.amia.org/sites/default/files/Joint-Work-Force-Task-Force-2008.pdf.

[21] Health Informatics Society of Australia, Health Informatics Competency Framework 2013, 2018 (accessed 18 May 2018), http://www.healthinformaticscertification.com/wp-content/uploads/2016/02/CHIA-competencies-Framework_FINAL.pdf.

[22] H.-F. Hsieh, S.E. Shannon, Three approaches to qualitative content analysis, Qual. Health Res. 15 (2005) 1277–1288.

[23] J.W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Method Approaches, 4th ed., SAGE Publications, Thousand Oaks, California, 2014.

[24] M. Almalki, M. Househ, M. Alhefzi, Developing a Saudi health informatics competency framework: a comparative assessment, Stud. Health Technol. Inform. 264 (2019) 1101–1105, https://doi.org/10.3233/shti190396.

[25] D.R. Krathwohl, A Revision of Bloom's Taxonomy: An overview, Theory Pract. 41 (4) (2002) 212–218, https://doi.org/10.1207/s15430421tip4104_2.

[26] Digital Health Canada, Health Informatics Professional Core Competencies, 2020 https://digitalhealthcanada.com/wp-content/uploads/2017/03/Health-Informatics-Core- Competencies.pdf [accessed April 20, 2020].

[27] A.H. Sapci, H.A. Sapci, Teaching hands-on informatics skills to future health informaticians: a competency framework proposal and analysis of health care informatics curricula, JMIR Med. Inform. 8 (1) (2020) e15748, https://doi.org/10.2196/15748.

[28] C.S. Gadd, E.B. Steen, C.M. Caro, S. Greenberg, J.J. Williamson, D.B. Fridsma, Domains, tasks, and knowledge for health informatics practice: results of a practice analysis, J. Am. Med. Inform. Assoc. 27 (6) (2020) 845–852, https://doi.org/10.1093/jamia/ocaa018.

[29] M.A. Meyer, Healthcare data scientist qualifications, skills, and job focus: a content analysis of job postings, J. Am. Med. Inform. Assoc. 26 (5) (2019) 383–391, https://doi.org/10.1093/jamia/ocy181.