A Digital Health Evaluation Framework

Elizabeth M. BORYCKI*, Amr FARGHALI, Amanda L. JOSEPH, Ryan KLETKE, Helen MONKMAN, Eleah STRINGER, and Andre W. KUSHNIRUK

School of Health Information Science, University of Victoria, Human and Social Development Building, Room 202, V8N 2G7, Victoria, Canada
E-mail (*): emb@uvic.ca

* Author to whom correspondence should be addressed

Abstract
Purpose: Digital health evaluation frameworks are needed to guide the development, implementation and evaluation of innovative, integrated systems of digital care. In this paper we describe a framework that was developed to evaluate the implementation of digital health technologies at a regional level. *Materials and Methods:* The framework was developed in a series of iterative phases beginning with a review of digital health frameworks used in Canada, which was followed by a scoping review focused on frameworks, models and theories used internationally to evaluate digital health technologies. Data extracted from articles were analyzed thematically to arrive at factors, concepts and measures that were incorporated in the final version of the framework following researcher discussions. *Results:* A range of themes and concepts emerged in the areas of: (1) organizational and context factors, (2) system, (3) use and process, and (4) outcomes. *Conclusions:* Several new themes and concepts were identified and incorporated into the new digital health evaluation framework.

Keywords: Digital Health Evaluation Framework; Health Informatics; Evaluation; Framework; Model; Theory

Introduction

A healthcare sector priority has been to connect primary, community, acute care and long-term care settings using digital health technologies. Over the past 50 years, considerable efforts have been made to digitize healthcare; for example, greater than 90% of physicians use electronic medical records (EMRs) in most OECD (i.e., Organization of Economic Cooperation and Development) countries. Yet, healthcare providers continue to record patient health information in their own EMRs without being able to digitally exchange this data with other healthcare organizations (e.g., regional health authorities, clinics, hospitals) [1]. This may lead to digital fragmentation of information, unnecessary interactions, and errors in the transmission of patient information across organizations. Researchers have identified a need to provide digital care in a meaningful way to prevent fragmentation of patient information [2, 3]. To address this issue, researchers and policy makers have identified a need for digital health evaluation frameworks to understand the effects of digital systems of care upon patients and health professionals [4-5]. In this paper we present a framework developed following a review of digital health frameworks in Canada [i.e., 6] and a scoping review. Our work aimed to create a framework for evaluating key aspects of digital health technologies and systems of care. The findings represent a contribution to the digital health and health informatics literature's as digital health frameworks have historically focused on individual health technologies, rather than digital health systems of care.

Elizabeth BORYCKI, Amr FARGHALI, Amanda JOSEPH, Ryan KLETKE, Helen MONKMAN, Eleah STRINGER, and Andre KUSHNIRUK

Materials and Methods

A scoping review was conducted using Arskey and O'Malley's approach [7]. The PubMed®, EBSCOhost®, CINAHL®, Web of Science®, and IEEE Xplore® databases were searched for the years 2010 to 2020 using the terms "evaluation" AND (framework or model or theory) AND "health information system". Identified articles were then uploaded to Covidence® [see 8], for title and abstract screening by three researchers using the criteria in Table 1.

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
- Written in English - Evaluated health information system(s) - A framework, model or theory used to develop, test, extend and/or evaluate a health information system(s)	- Not written in English - An opinion or review article - A medical device study - A description of a database that stores data - A study focused on a clinical problem

A final set of articles were identified and a full review of each paper took place. Identified articles and documents, which met the eligibility criteria were read, and relevant data were extracted (i.e., researcher name, date of publication, research questions, model/framework/theory and documented dimensions and concepts, subjects/participants, setting, methods, findings, and conclusions) [7]. Data were analyzed for themes and concepts to develop and extend the framework. This work involved researchers, reviewing the extracted scoping review data, including the themes and concepts and extending the framework through discussion [9].

Results

Three hundred sixty-three articles were identified; 78 duplicates were removed. The titles and abstracts of 285 articles were screened using the inclusion and exclusion criteria in Table 1. Two hundred fifteen items were excluded as they did not meet the criteria. Seventy articles were assessed for their eligibility with a full review of each article. Seventeen articles were excluded after a full review as they did not meet the criteria in Table 1. Fifty-three articles remained for data extraction. A thematic analysis of the data extractions was conducted. The following themes emerged: (1) organizational and contextual factors, (2) system, (3) use and process, and (4) outcomes. New concepts that emerged under the "system" theme were reliability, privacy and usability. Under the theme "use and process" new concepts included user characteristics, needs, and experience as well as workflow. Implementation emerged as an essential concept that included several important aspects of digital health implementation. Outcomes included new concepts such as quality of decision making, quality of care and others. Figure 1 shows the complete evaluation framework, including the set of factors, concepts, and measures that could be considered when evaluating digital health systems of care. We developed this framework through an iterative process. Initially, we drew on the previously accepted Canada Health Infoway's Benefits Evaluation Framework, that incorporates aspects of DeLone and McLean's work [10], and we also drew on Donabedian's system structure, process, and outcome quality model for healthcare [11]. We then integrated themes and concepts from our scoping review through researcher discussion (see Figure 1).
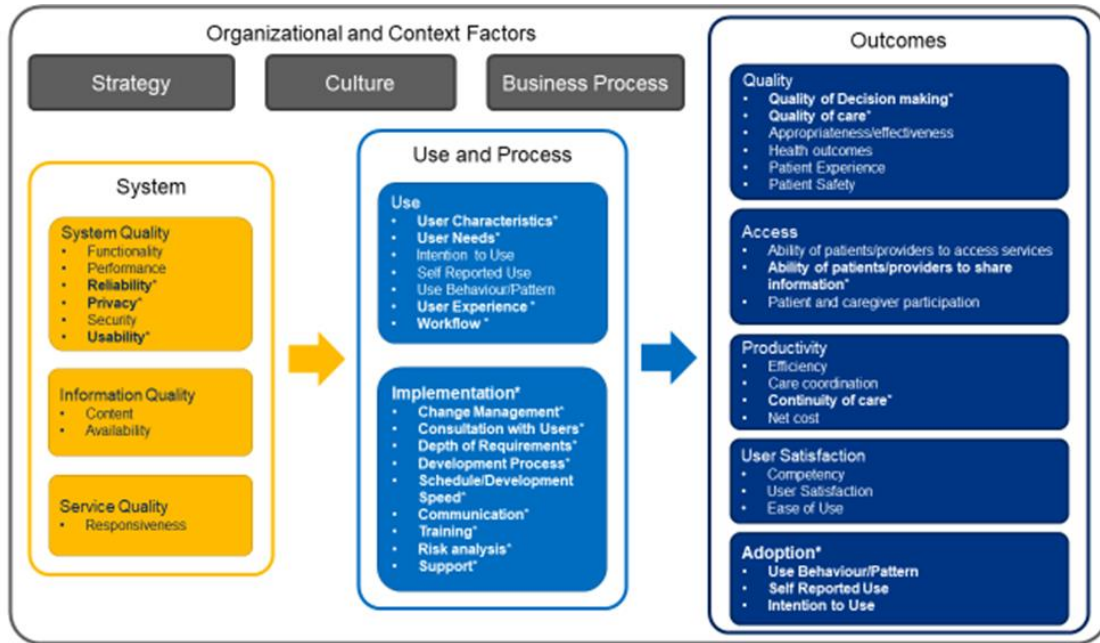
Figure 1. Digital health evaluation framework

Conclusions

The framework described in this paper was used to drive an evaluation of a regional digital health technology implementation. The framework offers an approach to studying digital health systems of care and guiding their evaluation. As technologies are integrated into digital health systems of care we need to consider past frameworks as well as new themes and concepts that have emerged and need to be integrated into developing evaluation frameworks. It should be noted that such frameworks can be designed to provide a superset of themes and concepts and could be considered as guidance for policy makers for inclusion in particular digital system of care evaluation projects. The development of evaluation protocols, such as questionnaires and interview prompts using the framework will vary depending on the themes and concepts selected.

References

1. OECD. Health at a glance 2021: OECD indicators, OECD Publishing, Paris, 2021. [cited 03/11/2024] Available from: https://doi.org/10.1787/ae3016b9-en.

2. Senathirajah Y, Kaufman DR, Cato KD, Borycki EM, Fawcett JA, Kushniruk AW. Characterizing and visualizing display and task fragmentation in the electronic health record: Mixed methods design. JMIR Hum Factors. 2020;7(4):e18484. doi: 10.2196/18484.

3. Borycki EM, Farghali A, Kushniruk AW. Integrating human patterns of qualitative coding with machine learning: A pilot study involving technology-induced error incident reports. Stud Health Technol Inform. 2022;295:276-280. doi: 10.3233/SHTI220716.

4. Tran Ngoc C, Bigirimana N, Muneene D, Bataringaya JE, Barango P, Eskandar H, et al. Conclusions of the digital health hub of the Transform Africa Summit (2018): strong government leadership and public-private-partnerships are key prerequisites for sustainable scale up of digital health in Africa. BMC Proc. 2018;12(Suppl 11):17. doi: 10.1186/s12919-018-0156-3.

5. Joseph AL, Stringer E, Borycki EM, Kushniruk AW. Evaluative frameworks and models for health information Systems (HIS) and health information technologies (HIT). Stud Health Technol Inform. 2022;289:280-285. doi: 10.3233/SHTI210914.

6. Lau F, Hagens S, Muttitt S. A proposed benefits evaluation framework for health information systems in Canada. Healthc Q. 2007;10(1):112-116, 118.

7. Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. Int J Soc Res Methodol. 2005;8:19-32. doi: 10.1080/1364557032000119616.

8. Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available from: www.covidence.org.

9. Zhang Y, Wildemuth BM. Qualitative analysis of content. In: B. M. Wildemuth, Ed., Applications of Social Research Methods to Questions in Information and Library Science, Libraries Unlimited, 2009. pp. 1-12.

10. DeLone WH, McLean ER. The DeLone and McLean model of information systems success: a ten-year update. J Manag Inf Syst. 2003;19(4):9-30. doi: 10.1080/07421222.2003.11045748.

11. Donabedian A. The quality of care. How can it be assessed? JAMA. 1988;260(12):1743-8. doi: 10.1001/jama.260.12.1743.