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Research Article

Development and Validation of a Workflow Instrument to Evaluate the Success of Electronic Health Records Implementation from a Nursing Perspective: An Exploratory and Descriptive Study

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ABSTRACT

Introduction: Electronic medical records (EMR) have been recognized as practical tools for the improvement of the quality and safety of healthcare despite their occasional use in hospitals worldwide. Epic is an integrated software suite with functionality ranging from patient administration through systems for healthcare providers to billing systems, integration to the primary health sector, and a facility for granting patients access to their data. The implementation process is complicated; creating effective methods requires understanding users' attitudes about these information technologies. This study aimed to develop and validate a questionnaire that measures the efficacy of using workflow during the EMR (Epic) implementation. Furthermore, it describes the nurses' views on the use of quality and satisfaction of workflow. **Methods:** Following a literature review, an initial pool of 57 items was generated based on the following three primary constructs: use, quality, and user satisfaction with the tool's workflow. Internal consistency reliability was assessed by calculating Cronbach's alpha and correlation coefficients for construct validity. **Results:** The final scale comprised 53 items corresponding to the following five distinct factors: use of workflow, information quality, service quality, use of EMR, and user satisfaction and the influence of workflow on clinical care. The full scale was assessed, and Cronbach's alpha of 0.95 was found. The construct validity was assessed using the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's Test of Sphericity (0.976). Construct validity was tested twice using Exploratory Factor Analysis-Principal Component Analysis. **Conclusion:** The use of workflow, quality of information, quality of service, use of EMR, and user satisfaction scale have good reliability and validity and can be used to implement technology in healthcare.

Keywords: workflow, electronic medical record, health information system, instrument validation, questionnaire, nursing

INTRODUCTION

Electronic medical records (EMR) have been recognized as practical tools for the improvement of the quality and safety of healthcare despite their occasional use in hospitals worldwide.[1] Epic is an integrated software suite with functionality ranging from patient administration through systems for healthcare providers to billing systems, integration to the primary health sector, and a facility for granting patients access to their data.[2] The implementation process is complicated; creating effective methods requires thoroughly understanding users' attitudes about these information technologies (IT).[3]

Normalization process theory was used to provide a framework of workflows that describe the work processes, facilitate the successful implementation of health information system (HIS) intervention in complex practices, and support clinical decisions across diverse healthcare settings.[4,5] The potential implementation gaps, such as risk assessment, customization, usability testing, and training, must be preidentified during the technology implementation.[6] Technological and organizational strategies must be developed by adopting hospitals' or systems' suppliers to promote the safety of introducing electronic systems design, implementation, and use.[7] Technology adoption can be effectively achieved with appropriate preparation, such as a straightforward workflow process.[8] Therefore, a record that is well integrated with workflow components optimizes efficiency, maintains data integrity and reliable reports, minimizes mistakes, and supports time is necessary for an effective workflow.[9]

Owing to new technology and clinical practice treatment paradigms, healthcare workflow creation is more critical today.[10,11] Health systems frequently organize their processes to assume a workflow structure implicitly.[12] Nurses guard a wealth of knowledge, which may be lost when inefficient workflows hinder cooperation and communication or increase interruptions.[13] Integrating health IT into clinical and organizational workflows can improve efficiency and reduce redundant information.[14] For example, barcode medication administration and/or scanning barcodes off a key ring rather than the patient can be implemented as workflow solutions.[15]

Understanding the clinical workflow before implementation helps redesign systems and processes to streamline the workflow rather than complicate it.[16–18] For example, pharmacy and nursing staff have reported that new procedures improved their workflows through planning; however, workflow issues may inhibit technology adoption.[19] A balanced workflow can improve efficiency, effectiveness, and use of subprocess dynamics within perioperative and central sterile supply activities.[20] Recent studies have demonstrated that HIS provides measurable benefits; however, some data show user dissatisfaction, which underscores the significance of strong leadership and staff "buy-in" when refining implementation techniques and integrating health IT into the workflow.[21]

The successful integration of EMRs using a well-mapped workflow that embraces the six domains of quality (safety, effectiveness, patient-centered, efficiency, timely, and equity)[22] enables the rapid uptake of a new service and avoids the challenges associated with adopting new technology.[23] So far, no validated instruments have assessed the views, quality, and satisfaction with workflow as a measure of EMR implementation and integration. Workflow evaluation from the user's viewpoint, especially from nurses, has received little attention and consideration. Furthermore, international and national evidence on assessing nurses' workflow is scarce.[24]

This study was conducted to develop and validate a questionnaire that measures the efficacy of using workflows during the EMR implementation. Furthermore, it describes the nurses' views on workflow use, quality, and satisfaction. We believe this study will benefit the deployment and integration of information management in hospitals throughout Saudi Arabia.

METHODS

This study was approved by the Nursing Research Committee and the Institutional Review Board (IRB) at King Fahad Medical City. The study followed the guidelines of the Declaration of Helsinki. All participants were informed about anonymity, confidentiality, and the option of voluntary termination at any time without any repercussions on their current or future work. Participants who consented to participate were enrolled in the study and asked to complete the required surveys.

Study Population

The investigators recruited participants from all nursing departments in a tertiary hospital in Saudi Arabia using a cross-sectional, descriptive, exploratory design. A total of 1236 participants were recruited over 3 months for the study. Inclusion criteria included the nurses involved in EMR (Epic) implementation and integration and using workflows in their daily clinical work. Exclusion criteria were nurses who did not complete the 3-month probationary period, worked in nonclinical settings, and did not use Epic.

The target sample size was estimated for a cross-sectional study using Raosoft. For this exploratory psychometric study, 20 participants were considered per question; 57 questions multiplied by 20 participants equaled a sample size of 1140.

Data Collection

A panel review of expert nurses in nursing informatics, quality, clinical practice, and administration (leadership and management) addressed the instrument's face and content validity. A questionnaire was developed to assess the role and importance of using the workflow when adapting HIS, such as EMR, based on previous literature[11] and suggestions of the nursing informatics team. The questionnaire was designed to measure three domains, defined as use, quality, and user satisfaction with the workflow. The developed questionnaire underwent reliability and validity testing.

At the time of data collection, the questionnaire was sent by the nursing affairs office to all participants via their work emails with all details regarding the study, including the eligibility criteria, IRB, and the contact details of the research team.

The first part of the questionnaire was used to obtain participants' sociodemographic data, which include sex, age, education, work category, professional title, area of work,

years of experience in nursing and the hospital, computer skills, years of using EMR, previous training, access privilege, and previous experience in mapping/designing workflow for EMR (total of 13 questions). The remaining questionnaire consisted of 57 questions across the three domains, and a five-point Likert scale was used to evaluate all items.

- *Use of Workflow*: 19 items were used to assess the use of workflow, which is defined as the nurses' attitude or opinion about the use of the workflow when performing patient care-related tasks using the EMR. These tasks included patient arrival, registration, patient preparation, resources/services request, nursing care management, and discharge planning). Responses were assigned a value of 1 for "strongly disagree" to 5 for "strongly agree" for each item.
- *Quality of Workflow*: 24 items were used to assess the quality of the workflow, which is defined as the quality of the workflow, its output, and its responsiveness in terms of the accuracy of the information, thereby driving and improving the nurses' performance and clinical judgment as well as the efficacy of the workflow to reinforce the use of the EMR. The questions were categorized under information quality, service quality, and EMR use. Responses were assigned a value of 1 for "never/almost never" to 5 for "always/almost always" for each item.
- *User Satisfaction*: 14 items were used to assess satisfaction, which is defined as the extent to which nurses believe the workflow is essential in improving their work and satisfaction. The questions were categorized to assess the impact of workflow on clinical care and overall (global) satisfaction. Responses were assigned a value of 1 for "not at all" to 5 for "very great" for each item.

Statistical Analysis

IBM SPSS version 22 was used to analyze data using descriptive statistics to examine the distribution of data values, including outliers and patterns of missing values. All nominal and ordinal data were reported in frequencies and percentages, and numerical data were reported in terms of mean and SDs. Both negative and positive items were reported as frequencies and percentages. To strengthen the results, the positive (rank 4 and 5) and negative (rank 1 and 2) responses of each domain/variable were merged for analysis.

Test of normality

A normality test was performed to assess whether the data were normally distributed. Kolmogorov–Smirnov test was selected because the sample size was 1097 ($n \geq 50$). The results showed that the data were significantly different ($p \leq 0.001$); hence, nonparametric tests were selected (Table S1).

RESULTS

Participants Characteristics

A total of 1097 subjects were involved in the analysis (88.75% response rate). Most participants were females (92.9%), older than 35 years old (52.1%), holding a bachelor's degree (82.8%), working in a clinical field (91.5%) as registered nurses (78.6%) in inpatient settings (55.4%), with more than 15 years of nursing experience (33.1%), and more than 10 years of experience in the current hospital (31.5%). The majority of participants had an intermediate level of computer skills (38.2%) and experience using Epic for 1-5 years (44.8%). Of the participants, 77.3% received Epic training, 59.5%) were end-users, and (2.4% had no experience designing workflow (Table 1).

Description of Participant Responses

Table S2 shows participants' responses across the 57 items, with a mean rank of 4 for each item (Likert scale of 1-5); however, variations were noted in the upper and lower quartiles in each of the three domains. Table S2 also demonstrates a descriptive frequency analysis that displays the nurses' positive and negative responses.

Table S3 demonstrates the means of the total scores for the domains and subdomains of the newly proposed workflow instrument. Regarding the quality of workflow, items of information quality scored the highest means, followed by the items of Epic. In contrast, items for service quality scored the lowest means. Concerning user satisfaction with the use of workflow, the means for the first 10 items evaluated the impact of workflow on clinical care more than that of the four items about satisfaction, except item 57.

Use of workflow

Most nurses (91.%) believed the workflow guided them to document all activities (e.g., physician orders). On the other hand, the highest responses held negative (7.3%) or neutral attitudes (16.3%) regarding the use of workflow to alert managers and leaders about changes in department status.

Quality of workflow

Most nurses (86.4%) thought that workflow helps facilitate implementing and integrating Epic into practice. On the other hand, the highest negative responses (11.4%) were about how effective the workflow was in omitting unnecessary pauses and rework, delays, and establishing workarounds. When asked about the efficiency of the workflow in reducing unnecessary interruptions, the most neutral responses (18.2%) were observed.

User satisfaction

Most nurses (84.%) believed workflow was practical. On the other hand, the highest responses held negative (6.5%) or neutral attitudes (36.1%) about the lack of training could impede workflow.

Table 1. Participants' characteristics ($N = 1097$)

Variables	*n* (%)
Sex	
Male	78 (7.1)
Female	1019 (92.9)
Age (years)	
≤ 25	21 (1.9)
26–30	149 (13.6)
31–35	356 (32.5)
> 35	571 (52.1)
Educational Level	
Diploma	139 (12.7)
Bachelor	908 (82.8)
Master	45 (4.1)
Other	5 (0.5)
Work Category	
Clinical	1004 (91.5)
Academic	22 (2.0)
Quality	16 (1.5)
Administrative	53 (4.8)
Informatics	2 (0.2)
Professional Title	
Registered Nurse	862 (78.6)
Shift Manager	160 (14.6)
Unit Manager	56 (5.1)
Nurse Manager	10 (0.9)
Clinical Instructor	2 (0.2)
Nurse Educator	1 (0.1)
Senior Nurse Educator	1 (0.1)
Nursing Director	5 (0.5)
Area of Work	
ICU	48 (4.40)
ED	140 (12.8)
Outpatient	253 (23.1)
Inpatient	608 (55.4)
OR	43 (3.90)
Education	5 (0.50)
Years of Experience in Nursing	
≤5	121 (11.0)
6–10	317 (28.9)
11–15	296 (27.0)
>15	363 (33.1)
Years of Experience in the current hospital	
<1	22 (2.0)
1–5	426 (38.8)
6–10	303 (27.6)
>10	346 (31.5)
Rate your computer skills	
Basic	315 (28.7)
Intermediate	419 (38.2)
Advanced	289 (26.3)
Proficient	74 (6.7)
Years of using EMR	
≤1	340 (31.0)
1–5	491 (44.8)
6–10	168 (15.3)
>10	98 (8.9)
Did you receive any training on the use of EMR?	
Yes	848 (77.3)
No	249 (22.7)
What access privilege do you have in EMR?	
End-user	653 (59.5)
Superuser	208 (19.0)
Master	64 (5.8)
Cogito	17 (1.5)
Credential Manager	19 (1.7)
No access	136 (12.4)
Do you have previous experience in mapping/designing a workflow for EMR, such as Epic?	
Yes	193 (17.6)
No	904 (82.4)

ICU: intensive care unit; ED: emergency department; OR: operating room; EMR: electronic medical record.

Internal Consistency of the Workflow Instrument

Table 2 demonstrates Cronbach's alpha for the five extracted factors in the workflow instrument. All factors show high internal consistency values. The highest value was related to factor 1 use of workflow ($\alpha = 0.98$). In contrast, the lowest internal consistency value was related to the factor four use of EMR ($\alpha = 0.91$). The overall Cronbach's alpha is 0.95.

Table 3 demonstrates Spearman's Correlation Coefficients matrix between the five extracted factors of the workflow instrument. The overall correlation ranged between ($r_s = 0.44$) and ($r_s = 0.68$). The highest correlation was found between factor two of information quality and factor three of service quality ($r_s = 0.68$). In contrast, the lowest correlation coefficient was found between factor one of use of workflow and factor three of service quality ($r_s = 0.44$).

Construct Validity of The Workflow Instrument

The items extracted based on an extensive literature review were then evaluated and scrutinized for face validity by a panel of nursing experts with different backgrounds (informatics, quality, administration, and clinical operations). After that, the instrument was developed, reviewed by the research team, and sent to the participants.

The initial questionnaire consisted of 57 items that were grouped into 3 domains and 10 subdomains as follows: (1) Use of Workflow—subdomains (a) patient's

Table 2. Internal consistency of the extracted factors

Domains	Cronbach's Alpha
Factor 1 (19 Items 1–19): Use of Workflow	0.98
Factor 2 (9 Items 20–28): Information Quality	0.95
Factor 3 (6 Items 32–37): Service Quality	0.93
Factor 4 (6 Items 38–43): Use of Electronic Medical Records	0.91
Factor 5 (13 Items 44–57, except item 54): User Satisfaction & Impact of Workflow on Clinical Care	0.96

Coefficient of Cronbach's alpha-internal consistency: $0.9 \leq \alpha$ (excellent), $0.8 \leq \alpha < 0.9$ (good), $0.7 \leq \alpha < 0.8$ (acceptable), $0.6 \leq \alpha < 0.7$ (questionable), $0.5 \leq \alpha < 0.6$ (poor), $0.5 > \alpha$ (unacceptable).

Table 3. Factors correlation matrix

	Factor 1 (Use of Workflow)	Factor 2 (Information Quality)	Factor 3 (Service Quality)	Factor 4 (Use of EMR)	Factor 5 (User's Satisfaction & Impact of Workflow on Clinical Care)
Factor 1 (Use of Workflow)	1	0.530*	0.440*	0.490*	0.570*
Factor 2 (Information Quality)	0.530*	1	0.680*	0.660*	0.620*
Factor 3 (Service Quality)	0.440*	0.680*	1	0.660*	0.550*
Factor 4 (Use of EMR)	0.490*	0.660*	0.660*	1	0.660*
Factor 5 (User Satisfaction and Impact of Workflow on Clinical Care)	0.570*	0.620*	0.550*	0.660*	1

Spearman's correlation coefficient (r_s): 0.00–0.19 (very weak), 0.20–0.39 (weak), 0.40–0.59 (moderate), 0.60–0.79 (strong), 0.80–1.0 (very strong).
*Correlation is significant at the 0.01 level (2-tailed).
EMR: electronic medical record.

arrival and registration, (b) patient's preparation, (c) resources/services request, (d) nursing care management, and (e) discharge planning; 2) Quality of Workflow—subdomains (a) information quality, (b) service quality, and (c) use of Epic; 3) User—subdomains (a) the impact of workflow on clinical care and (b) global user satisfaction. This 57-item questionnaire was used to collect the data from the participants; then, it was evaluated for its validity and reliability.

Exploratory factor analysis using principal component analysis (EFA-PCA) with the Oblimin rotation method was used to construct the extracted factors from the workflow instrument with a recruited sample size ($n = 1097$) and cut-off loading factor ≥ 0.60.

The first run included 57 items, a ratio of 19.2:1 subject per item, and the model was appropriate based on the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity (0.976), $p < 0.001$, and $df = 1596$. The result has shown the following six factors were extracted: three items were below the cut-off loading factor (≤ 0.60), and 1 item loaded in factor 6; however, it was decided to delete the three items (items 29, 30, and 31) due to their poor loading, and not to use factor 6 because it has only one item (item 54) that has explained a low variance rate. The first run resulted in 53 items grouped into 5 factors. Furthermore, the items that describe the first domain were loaded into factor 2, items that describe the second domain were loaded into factor 4, items that describe the fourth domain were loaded into factor 5, and items that describe the fifth domain were loaded into factor 1. On the other hand, items that describe the third domain remained the same and were loaded into factor 3.

The second run included 53 items, a ratio of 20.7:1 subjects per item, and the model was appropriate based on the KMO measure of sampling adequacy and Bartlett's Test of Sphericity (0.976), $p < 0.001$, and $df = 1378$. The analysis has resulted in the following five factors that were labeled: (1) Use of Workflow (19 items), (2) Information Quality (9 items), (3) Service Quality (6 items), (4) Use of Epic (6 items), and (5) User Satisfaction and Impact of Workflow on Clinical Care (13 items). These five factors were able to explain 72.3% of workflow variance. Owing to changes in the arrangement of factors loading of each domain, the domains and their items were rearranged; therefore, the highest variance of the workflow was explained by the fifth domain of user satisfaction and the impact of workflow on clinical care (45.3%) that was loaded in factor 5, followed by the first domain of workflow usage (14.4%) that was loaded in factor 2. Further information is illustrated in Table 4 and Table S4.

DISCUSSION

This study describes the process of developing and validating an instrument to measure the effect of workflows on performing nursing activities during Epic implementation and integration. Testing the construct validity was done in two runs; hence, items loaded above 0.60, the minimum recommended value in

Table 4. Exploratory factor analysis-principal component analysis for total variance explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
Factor 1	24.012	45.306	45.306	24.012	45.306	45.306	18.379
Factor 2	7.648	14.431	59.737	7.648	14.431	59.737	17.688
Factor 3	3.249	6.131	65.868	3.249	6.131	65.868	9.242
Factor 4	2.085	3.934	69.802	2.085	3.934	69.802	16.742
Factor 5	1.330	2.509	72.311	1.330	2.509	72.311	10.361

This table reported the summary of the second round of the exploratory factor analysis that contained 53 items.

research, were considered, and those loaded below 0.60 were deleted[25,26]; therefore, items 29, 30, and 51 were deleted; therefore, 53 items were grouped into 5 factors—workflow, information quality, service quality, use of EMR, and user satisfaction—which were sufficient to outline the steps involved in providing healthcare, or the what, where, when, who, for how long, and in what order of each task.[27,28]

The workflow factor included 19 items describing the impact of using workflow and facilitating the completion of patient care–related tasks while introducing new healthcare information technology into clinical practice, such as Epic.[29,30] Therefore, a well-designed workflow reduces the time required to enter and retrieve patient clinical information, supporting the collaboration of healthcare providers, coordination of care, shared decision-making, and delivering high-quality care.[17,31–33] Additionally, direct patient contact, documentation, communicating results, and generating orders can be facilitated using efficient workflow.[18,34,35]

The information quality factor included nine items that described the advantages and pros of leveraging a workflow model during the implementation of Epic, which resulted in the identification of a standard methodology to support clinical practice and reduce the workarounds.[36,37] The service quality factor included six items that reduced the patients' safety risks, broader concerns about burnout, and clinical inefficiencies.[37] The workflow was highlighted in six items using the Epic factor. Developing appropriate strategies to familiarize nurses with the benefits of integrating IT in healthcare settings improved healthcare services.[38,39]

User satisfaction and the impact of workflow on clinical care factors included 13 items that described the importance of workflow in improving nurses' work. Moreover, the poorly designed workflow can limit the adoption or successful implementation of the EMR system.[40] Therefore, agile workflow facilitates completing tasks anywhere, anytime, making the clinical journey smoother with fewer disruptions.[41] Ongoing optimization strategies help to increase the motivation and likelihood of nurses remaining in the nursing workforce and reduce low well-being and burnout symptoms.[42]

Direct observation and quantitative studies of operational and clinical work can provide information about time spent managing various activities, their duration, frequency, and source of work disruptions and interruptions.[43] Hence, a well-structured workflow can guarantee the avoidance of such challenges when introducing electronic information systems or applications in the healthcare field.[44,45]

Significant challenges have been observed because of the absence of interoperability and standardization of interfaces among these systems, hindering the efficient collaboration and exchange of information in managing intricate patients. The EMR is an innovative technology that has the potential to transform the way we provide healthcare to our patients completely.[46] The barriers to adoption and use that were frequently observed included resource limitations, inadequate training and technical support for users, as well as low literacy and technological skills.[47] The success of the EHR technology ultimately hinged on several key factors, including usability, interoperability, adaptability, infrastructure, regulation, standards and policies, and testing.[48] After looking at this from all sides, the health transformation will improve the infrastructure of digital technologies, including EMR.[49]

Strengths

This study aimed to develop and validate a scale rather than describe nurses' attitudes using a generalizable sample. Scale items were generated through a participatory process engaging nursing experts. The scale underwent EFA-PCA to assess the validity and reliability using a large sample of participants. Epic is currently widely used in the United States, which means there are extremely experienced users and IT professionals who could collaborate in manipulating the software and training staff.

Limitations

The literature about workflow is scarce and only about health information systems and workflows. While the scale items may be adapted to other contexts, items were developed to focus on the nurses' perspectives in the hospital. Other healthcare professionals' perspectives were not assessed, which may affect EMR's full implementation and integration throughout the hospital.

Nurses have perceived learning new software such as EMR as annoying and disturbing; therefore, institutional training would quickly prepare them and allow everyone to come up to speed before implementing new workflow processes, thus minimizing anxiety and resistance to change.

Implications of Nursing Practice

HIS are designed and implemented to improve nurses' performance and help them plan and make patient care decisions. To facilitate their implementation and enhance their use, nurses require training and proper guidance, such as a well-designed workflow to save time, delay documentation registration, and increase nurses' motivation, satisfaction, and sense of job security.[50]

CONCLUSION

The use of workflow, quality of information, quality of service, use of EMR, and user satisfaction scale have good reliability and validity and can be used to implement technology in healthcare. This questionnaire was used to evaluate nurse's workflow use, information quality, service quality, use of EMR, user satisfaction, and workflow's impact on clinical care using Epic in healthcare settings. Owing to the interconnected nature of clinical work, new technology may have unintended

consequences. A thorough understanding of clinical workflow helps anticipate and contain these unintended consequences.

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Data Availability

Complete study data are available upon request by contacting the corresponding author.

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