

A Methodology for Meeting Context-Specific Information Needs Related to Nursing Orders

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Abstract

Nurse information needs at the point of care exist; however, once provided with access to resources, nurses seek evidence-based answers. The success of answering an information need through an automated Infobutton relies on the program's ability to anticipate a clinician's question. This study's six process methodology aims to meet context-specific information needs related to clinical information system (CIS) nursing orders. Context-specific questions were derived from nurse generic questions generated from nurse focus group data, observational data, and an established taxonomy. The context-specific questions, were filtered by nursing order semantic type within a logical clinical context cluster (LCCC), which is a clinical association identified from the nurse perspective. Nursing orders of the same semantic type are associated with similar types of nurse information needs and are used to assess Internet-based resources for the capability to answer those information needs. LCCCs help identify resources and CIS areas ripe for an Infobutton.

Introduction

Unmet information needs in the clinical setting have been found to occur frequently.¹ However, encouraging evidence has shown that nurse utilization of knowledge-based electronic information resources increased when nurses were provided with electronic information access at the point-of-care.² Nurse adaptability to electronic information resources provides a rich opportunity to decrease information needs gaps for nurses.

The Infobutton project at Columbia University analyzed observational data of clinicians using a clinical information system (CIS) to develop an Information Needs Event taxonomy, including generic clinical questions.¹ The taxonomy characterizes the types of needs, the contexts in which the needs arose, how the users attempted to address their needs, and how successful those attempts were.¹ The Infobutton displays generic clinical questions that are anticipated based on prior

studies of observational data.¹ The Infobutton Manager utilizes context-specific information from the clinical information system (CIS) to link the questions between the CIS and appropriate information resources.³

Accurate characterization of clinician information needs with identification of potential resources is a significant and necessary process to provide information that meets the Joint Commission on Accreditation of Healthcare Organizations' (JCAHO) standards requirement that knowledge-based resources are readily available, current, and authoritative.⁴ Moreover, characterizing information needs provides insight to ensure that information resources are appropriate, timely, and useful to clinicians providing patient care. Information need events have been shown to occur within the context of nursing activities.¹ Computerized Provider Order Entry (CPOE) and CIS nursing orders are rich data sets of nursing procedure and documentation activities.

The purposes of this paper are: 1) To describe a methodology for meeting context-specific information needs related to nursing orders; and 2) To illustrate application of the methodology to a specific clinical context.

Methodology Overview

The methodology involved six processes: 1) Semantic type coding; 2) Identification of generic questions; 3) Identification of logical clinical context clusters (LCCCs); 4) Identification of context-specific questions; 5) Resource Identification and Retrieval; and 6) Resource Mapping (See figure 1). We use the context of intra-aortic balloon pump management to demonstrate this methodology.

Nursing orders for semantic type coding were obtained from the CIS at Columbia University Medical Center (CUMC) NewYork-Presbyterian Hospital (NYP) as a means to identify useful context specific nurse information resources. All semantic types used for categorization in this study had been previously incorporated into Columbia's Medical Entities Dictionary (MED), a semantic network

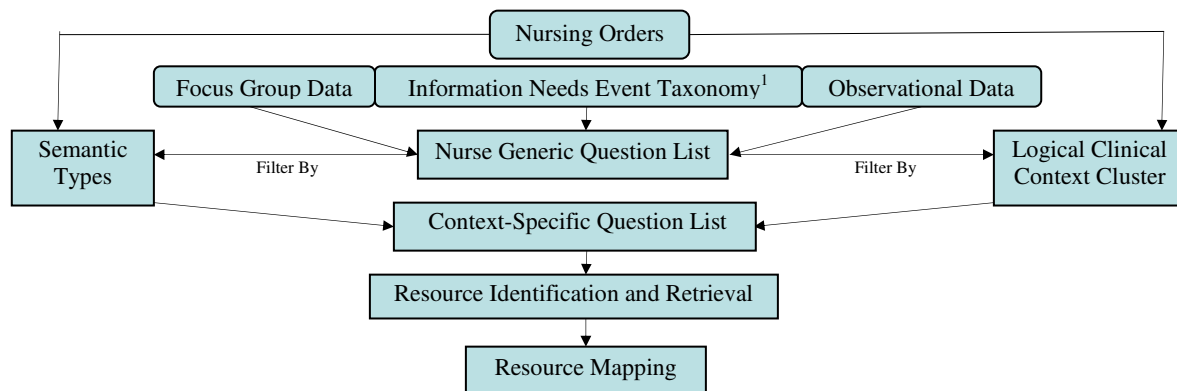


Figure 1. Methodology Flow Diagram

derived from the Unified Medical Language System (UMLS). The nurse generic question list was generated from three sources: analyses of nurse focus group data, Infobutton observational data, and an established taxonomy. The clinical contexts of the nursing orders were categorized into LCCCs, with the intent that this organization would facilitate use in a documentation interface. Context-specific information needs were derived from the nurse generic question list and filtered by the semantic types of the nursing orders within the LCCC of interest. The LCCC associated with the derived context-specific question list was used to search and retrieve Internet-based resources and to recognize areas within nursing documentation suitable for Infobutton implementation. The identified resources were mapped using the context-specific question list and semantic type of each nursing order to evaluate the capability of each resource to answer nurses' questions.

IRB approval for clinical observation and for focus groups was obtained as part of the Infobutton project and the Wireless Informatics for Safe and Evidence-based Advanced Practice Nursing (WISE-APN) project at Columbia University School of Nursing.

Categorization of Nurse Orders by Semantic Type

The categorization of nursing orders by semantic type was conducted by two nurse informaticists experienced in critical care nursing using semantic types identified in the UMLS. The purpose of this categorization was to aggregate nursing orders by semantic type in order to efficiently link them to a set of generic nurse questions. Inter-rater reliability among the two nurse informaticists for the classification of semantic types was performed on a random sample of 14 percent of the nursing orders.

Nurse Generic Question List

The nurse generic question list derivation process identified questions with the logical ability to represent an information need associated with a semantic type (e.g., equipment, alert/precaution). Three data sources were used to ensure a comprehensive nurse generic question list: Focus

group data, Infobutton observational data, and Information Need Event taxonomy¹ with generic physician questions from Ely et al.⁶

A focus group, consisting of four student nurses from the Columbia University School of Nursing, took place in November of 2006 with the aim to elicit information needs in the context of hazards and near-miss events reporting (i.e., events that may have led to an error if not intervened upon).⁵ A sub-analysis was performed on the data to identify the nurse generic question list.

Observational data of nurses using a CIS on inpatient medical/surgical floors were collected for the Infobutton project from 2003 to 2006 at CUMC-NYP. The observational data were collected using Morae™ software as the portable usability laboratory during randomly selected periods of time.¹ For this study a sub-analysis of the data was completed to obtain nurse questions not captured in the Information Need Event taxonomy.¹ The Information Needs Event taxonomy, developed by Currie et al.¹, characterizes the type and context of clinician information needs.

Lastly, the comprehensive nurse generic question list was synthesized to combine questions that were seeking the same information but through different syntactical forms, such as "What are the possible adverse events of X?" and "What adverse events are caused by X?". The formulation of the nurse generic question list was completed by one nurse informaticist (SC) and iteratively validated by two other nurse informaticists (SB and LC).

Identification of LCCCs

Qualitative analysis was used to identify LCCC relationships of nursing orders. The LCCCs are logical relationships, determined from the critical care nurse perspective, that cluster domain elements that exist across multiple contexts. For example, the domain of *fluid status* may exist within the patient assessment context, implementation context, documentation context, and evaluation context of nursing care. All nursing orders were assessed for

their ability to be categorized into a clinical context; however, not all orders were appropriate to categorize within a clinical context, nor were the clinical contexts intended to be mutually exclusive. The LCCC chosen for in-depth analysis was identified due to its inclusion of nursing orders with multiple semantic types and its clinical significance and complexity, as determined by the consensus of three experienced critical care nurses.

Context-Specific Nurse Question List

Semantic type was used to filter the nurse generic question list for a chosen LCCC, intra-aortic balloon pump (IABP) management (described in more detail later) and resulted in the formation of a context-specific nurse question list. A generic question became part of the context-specific question list if the question was appropriate to at least one of the nursing orders' semantic types that were part of the LCCC of interest for that context-specific question list.

Resource Identification and Retrieval

The resource identification and retrieval process identified resources that may be capable of answering context-specific questions for an LCCC. Resources were used if they had verifiable content, were available through the Internet, and were commonly searched by clinicians.

Resource Mapping

The final process assessed each retrieved resource for its capability to answer each question for each

semantic type within the chosen LCCC. Resources were rated for their ability to answer semantically mapped nurses' questions for the chosen LCCC, IABP management.

Results

Categorization of Nurse Orders by Semantic Type

Seven hundred and forty-eight nursing orders were identified in the MED. From these orders, 21 UMLS semantic types were identified. The identified semantic types including counts in order of frequency are: alert/precaution (n=176), equipment (n=132), procedure (n=129), tube (n=50), notification (n=40), clinical measurement (n=37), position (n=31), activity (n=30), restraint (n=24), bedside laboratory (n=20), laboratory (n=20), medication (n=16), clinical assessment (n=16), vital signs (n=15), physical assessment (n=3), nutrition (n=3), clinical indication (n=2), referral (n=1), dressing (n=1), bedside procedure (n=1), and discharge (n=1). The IRR for semantic type coding was 74%.

Nurse Generic Question List

The nurse generic question list consisted of six questions. Table 1 lists each question and the data source from which the questions were derived.

Identification of LCCCs

We identified 26 LCCCs representing physiological or psychosocial clusters, nursing assessment clusters,

	Nurse Generic Question Intra Aortic Balloon Pump (IABP) Context-Specific Question	UpTo Date ^{6, a}	Net Library ^{9, a}	Pub Med ^{7, a, b}	Intra- net ^{8, a}
1	How do I (use equipment / use tube / do procedure X)?^{1,3} How do I use an IABP / use an IABP catheter / do an IABP insertion / measure an IABP ratio / measure augmented diastolic / do an IABP site check?	No	Yes	Yes	Yes
2	What is the Institution protocol for (equipment / tube / procedure / consent X)?^{1,3} What is the Institution protocol for an IABP / an IABP catheter / an IABP insertion / an IABP ratio / an augmented diastolic / an IABP site check?	No	No	No	Yes
3	What are the desired outcomes versus the undesired outcomes related to (equipment / tube / procedure X)?² What are the desired outcomes versus the undesired outcomes related to an IABP / an IABP catheter / an IABP insertion / an IABP ratio / an augmented diastolic / an IABP site check?	Yes	Yes	Yes	Part
4	What is the appropriate patient education related to (equipment / tube / procedure X)?² What is the appropriate patient education related to an IABP / an IABP catheter / an IABP insertion / an IABP site check?	No	No	No	Yes
5	What is the institution contact information to obtain (equipment / tube / procedure X protocol)?^{1,3} What is the institution contact information to obtain an IABP / an IABP catheter / the IABP insertion protocol?	No	No	No	No
6	What are the possible adverse events?^{1,2,3} What are the possible adverse events of an IABP / an IABP catheter / an IABP insertion / an IABP ratio / an augmented diastolic / an IABP site check?	Yes	Yes	Yes	Part
1. Focus Group Data 2. Infobutton Observational Data 3. Information Needs Event Taxonomy ¹		Search terms for resources: ^a intra-aortic balloon pump, ^b nurses Part – Partial capability to fulfill information need			

Table 1. Nurse Generic Question List and Resource Capability

and safety clusters. The identified LCCC used for this study was Intra-Aortic Balloon Pump (IABP). IABP consisted of 9 nursing orders. Table 2 lists IABP orders matched to semantic type; duplicate names show possible variations in representation.

IABP Nursing Orders	Semantic Type
Augmented Diastolic	Clinical measurement
Balloon Pump Machine IABP	Equipment
Balloon Site Checks	Clinical assessment
Intra Aortic Balloon Insertion	Procedure
Intra-aortic Balloon Insertion	Procedure
IABP	Equipment
Intra Aortic Balloon Catheters	Tube
Intra Aortic Balloon Pump	Equipment
IABP Ratio	Clinical measurement

Table 2. IABP Nursing Orders Semantic Types

Context-Specific Nurse Question List

Each semantic type within the IABP LCCC was found to be logically represented by at least four of the six generic questions. For each of the five semantic types represented in the IABP LCCC, an average of 5.4 of the 6 generic questions could logically be asked.

Questions 1, 2, 3 and 6 from the nurse generic question list could logically represent an information need for all 5 semantic types within the IABP LCCC. The IABP LCCC contained the following 5 semantic types: equipment, tube, procedure, clinical measurement and clinical assessment. Question 4 could logically answer an information need for all 5 semantic types except clinical measurement, such as the nursing order *IABP ratio*. Question 5 could logically answer an information need for all semantic types except clinical measurement and clinical assessment.

Therefore, for the identified LCCC, IABP, all of the existing semantic types were represented in the generic question list and all of the nursing generic questions were appropriate for the formation of the IABP nurse context-specific question list.

Resource Identification and Retrieval

The resources searched for content related to IABP were UpToDate, PubMed, Columbia University's NetLibrary, and the local Intranet (the NYP Infonet). UpToDate and PubMed were chosen based on their current use by the Infobutton project and general popularity amongst clinicians observed as part of the Infobutton data. The NetLibrary provides access to e-books and was chosen due to its accessibility by all staff at NYP through Columbia University's Health Sciences Library website. The Intranet was chosen for its ability to search NYP institutional guidelines. See Table 1 for the list of resources analyzed and for

the capability to answer the context-specific nurse questions.

UpToDate retrieved a ten page document: *Intraaortic balloon pump counterpulsation*.⁷ The PubMed search required the term "nurses" as a necessary step to narrow the search results. PubMed retrieved the 2006 Association of Operating Room Nurses article *Intra-aortic balloon pump therapy--a primer for perioperative nurses*.⁸ The Intranet search returned the NYP, Nursing Division, Critical Care Manual, *Intra-aortic Balloon Pump (IABP) (Datascope) Procedure*,⁹ a 13-page document. The NetLibrary search returned the searchable e-book *Cardiovascular Emergencies*.¹⁰

Resource Mapping

While UpToDate provided content specific to IABPs, Questions 1, 2, 4, and 5 were left unanswered. The PubMed article and the NetLibrary e-book performed the same as each other and slightly better than UpToDate by answering Question 1. Yet, PubMed and the NetLibrary, like UpToDate, left Questions 2, 4, and 5 unanswered. In contrast to UpToDate, PubMed, and the NetLibrary, the NYP IABP procedure guideline successfully answered Questions 1, 2, and 5. Furthermore, the NYP guideline provided content to answer Questions 3 and 6. However, the content for these questions was not presented in a format conducive to a "quick clinical look-up", therefore it was categorized as having partial capability to fulfill the information need.

Discussion

Coding of nursing order terms by semantic type proved a useful method to determine: 1) What are nurses' information needs?; 2) What questions are associated with each nursing order?; 3) What is the capability of an identified resource to answer each associated question?. The identification of an LCCC proved a useful mechanism to determine: 1) What are the search terms for resource identification and retrieval to answer context-specific questions?; 2) What is the clinical context to indicate where an Infobutton should be placed within an electronic nursing documentation system?.

Semantic typing of information resources has been done in the past using the UMLS to map the content of information resources to concepts within a user's information need question.¹¹ Additionally, the Dublin Core Metadata Element Set has also been used to encode document content to facilitate resource retrieval related to specific information needs,¹² however, no standard indexing terminology for these processes exists to-date. The 74% IRR resulted from

the clinical occurrence that nursing orders necessitate multiple implied nursing actions, such as obtaining equipment and performing a nursing procedure using that equipment; in such cases the generic questions proved sufficient to address both semantic types.

The methodology described herein determined nurses' information needs through the identification of nurses' clinical questions from focus group data, from observational data and from a previously established clinician information need taxonomy. Although surveillance is not an explicit question, it is inherent in questions 3 and 6. Generic nurse questions, capable of answering an information need related to one of the 21 semantic types, were further filtered by semantic type of each nursing order for a given LCCC to determine a context-specific question list. Four Internet-based resources were searched for content related to the chosen LCCC, IABP, and assessed for the capability to answer each context-specific nurse question. Resources performed differently, yet the ability of a resource to answer only one information need is still a significant success that may impact patient care. The LCCC identified may be used as a template to demonstrate the ability to relate nursing orders to each other.

As an academic medical center using a commercial CPOE system (Eclipsys XA™) it is likely that the nursing orders are representative in scope, content and structure. This research demonstrates that it is possible to determine the information need of a nurse by formulating a taxonomy of nurse generic question types based on a nursing order semantic type.

Nurses do not necessarily cognitively approach orders in a manner that reflects the same concept organization that exists in a CPOE system built for physicians to input orders. Rather, the nursing process, driven by procedural and documentation activities, follows LCCCs, which include, but are not limited to: physiological or psychosocial clusters, nursing assessment clusters, and safety clusters. Therefore, the ability to group nursing orders into LCCCs that reflect the nurses' process of clustering concepts may provide a method to implement point-of-documentation Infobutton links to useful context specific information that answers known nurse questions.

Nurse information needs theoretically may be predicted by an Infobutton according to nursing order semantic type and LCCC. The next step in this process is the integration of the nursing orders into the MED to allow for the automated generation of the resource link by the Infobutton Manager. Future analysis of Infobutton use data will indicate the usefulness of this methodology to nurses in practice.

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References

1. Currie LM, Graham M, Allen M, Bakken S, Patel V, Cimino JJ. Clinical information needs in context: an observational study of clinicians while using a clinical information system. AMIA 2003 Symposium Proceedings.
2. Tannery NH, Wessel CB, Epstein BA, Gadd CS. Hospital nurses' use of knowledge-based information resources. *Nursing Outlook*. 2007; 55:15-19.
3. Cimino JJ, Li J, Allen M, Currie LM, Graham M, Janetzki V, Lee NJ, Bakken S, Patel VL. Practical considerations for exploiting the World Wide Web to create infobuttons. *Medinfo*. 2004;11(Pt 1):277-81.
4. Management of Information. In: Joint Commission on Accreditation of Healthcare Organizations (JCAHO). 2004 Comprehensive Accreditation Manual for Hospitals. Oakbrook Terrace, IL; 2004:IM-4
5. Yen P., Bakken S. Information Needs Associated with Hazard and Near Miss Reporting. *Medinfo2007* (in press).
6. Ely JW, Osheroff JA, Gorman PN, Ebell MH, Chambliss ML, Pifer EA, Stavri PZ. A taxonomy of generic clinical questions: classification study. *BMJ*. 2000; 321:429-32.
7. Laham RJ, Aroesty JM. Intraaortic balloon pump counterpulsation. *UpToDate*. 2007. Accessed: 2/21/2007.
8. Tremper RS. Intra-aortic balloon pump therapy--a primer for perioperative nurses. *AORN J*. 2006 Jul;84(1):34-44. Accessed: PubMed 2/21/2007 <http://www.ncbi.nlm.nih.gov/arugula.cc.columbia.edu:2048/entrez/query.fcgi?otool=nycuhslib>
9. Intra-aortic Balloon Pump (IABP) (Datascope) Procedure. NYP, Nursing Division, Critical Care Manual. Accessed: 2/21/2007. <http://infonyet.nyp.org/>
10. Cardiovascular Emergencies by Davies, Crispin.; Bashir, Yaver. Publication: London BMJ Books, 2001. Accessed: 3/1/2007 <http://www.netlibrary.com.arugula.cc.columbia.edu>.
11. Humphreys BL, Lindberg DA. The UMLS project: making the conceptual connection between users and the information they need. *Bull Med Libr Assoc*. 1993 April; 81(2): 170-177.
12. Malet G, Munoz F, Appleyard R, Hersh W. A model for enhancing Internet medical document retrieval with "medical core metadata". *J Am Med Inform Assoc*. 1999 Mar-Apr;6(2):163-72.

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