Optimizing the Design of Preprinted Orders for Ambulatory Chemotherapy: Combining Oncology, Human Factors, and Graphic Design

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Abstract

Purpose: To establish a set of guidelines for developing ambulatory chemotherapy preprinted orders.

Methods: Multiple methods were used to develop the preprinted order guidelines. These included (A) a comprehensive literature review and an environmental scan; (B) analyses of field study observations and incident reports; (C) critical review of evidence from the literature and the field study observation analyses; (D) review of the draft guidelines by a clinical advisory group; and (E) collaboration with graphic designers to develop sample preprinted orders, refine the design guidelines, and format the resulting content.

Results: The *Guidelines for Developing Ambulatory Chemotherapy Preprinted Orders*, which consist of guidance on the design process, content, and graphic design elements of ambulatory chemotherapy preprinted orders, have been established.

Conclusion: Health care is a safety critical, dynamic, and complex sociotechnical system. Identifying safety risks in such a system and effectively addressing them often require the expertise of multiple disciplines. This study illustrates how human factors professionals, clinicians, and designers can leverage each other's expertise to uncover commonly overlooked patient safety hazards and to provide health care professionals with innovative, practical, and user-centered tools to minimize those hazards.

Introduction

Despite many efforts to digitize paper-based communication in health care, adoption of electronic health information systems has been slow. In 2008, the adoption rates of hospital-wide computerized physician order entry (CPOE) systems in seven countries (United States, United Kingdom, France, Australia, Germany, Switzerland, and the Netherlands) were 20% or less.¹ Given the many challenges associated with adopting electronic health information systems,^{1,2-8} paper forms will remain a necessity in health care for the foreseeable future.

Preprinted orders (PPOs), which are paper order forms with standard order information prefilled, are commonly used in health care. PPOs help simplify and standardize the ordering process because much of the basic information is already printed, such that the prescriber needs to write in only patient-specific information. Nevertheless, limited guidance exists about how PPOs should be designed to ensure appropriate, accurate, and efficient communication between health care professionals and thus to ensure patient safety. The only set of guidelines currently available about designing physician order forms with respect to patient safety is the *Guidelines for Standard Order Sets* published in 2010 by the Institute for Safe Medication Practices.⁹ The document provides guidance not only on content and approval/maintenance processes but also on the format of standard order sets, including layout, font style, font type, use of symbols, abbreviations, dose designations, and punctuation. However, the document is limited in that it does not provide the rationale behind most of its guidelines; therefore, it is difficult to appreciate the significance of the recommendations. Also, the document does not guide users with regard to how its design guidelines can be implemented. For example, although one of the guidelines states, "Separate

orders into logical groupings of treatment, procedure, and medication orders," it is not made clear how the separation between these groupings can be achieved on PPOs.

The importance of PPOs in health care coupled with the relatively scant attention that has been devoted to their design aspects has meant that a useful tool is often implemented at a less than optimal level, as discovered during a recent pan-Canadian research study on intravenous (IV) ambulatory chemotherapy safety.¹⁰ A national survey of Canadian cancer care organizations revealed that PPOs are the most commonly used communication tool for delivering chemotherapy in Canada. However, in the same study, a systematic risk analysis of the field study observations in six Canadian cancer care facilities using a Healthcare Failure Mode and Effects Analysis identified the risk of order communication failures associated with PPOs as a critical hazard. Moreover, the field study observations found that existing PPOs vary widely in format, content, and layout and do not provide the flexibility required for the dynamic needs of oncology ordering practices. Consequently, Canadian cancer care providers were experiencing communication failures that led to wrong drug, dose, or time errors. To address this issue, a group of human factors professionals, graphic designers, and clinicians collaborated to establish a set of development process, content, and design guidelines for ambulatory chemotherapy PPOs.

Human Factors

Human factors professionals apply knowledge about human capabilities and limitations (physical, sensory, emotional, and intellectual) to the design and development of tools, devices, systems, environments, and organizations.¹¹ Human factors professionals can have diverse backgrounds, including cognitive

psychology, industrial/systems engineering, kinesiology, and biomedical engineering. Although relatively new to health care compared with other complex sociotechnical industries such as aviation and nuclear energy, the application of human factors principles and methods is being increasingly sought out to address various patient safety issues. Examples include CPOE system adoption,¹²⁻¹³ medical device design and procurement,¹⁴⁻¹⁹ workspace design,²⁰ team coordination,²¹ and systematic risk management.^{18,22,23}

Graphic Designers

Graphic designers are experts at manipulating typography, white space, lines, and other visual elements. In addition, they are trained in perceptual psychology and are sensitive to the unique cultural and environmental aspects of different user groups. As a result, graphic designers are capable of producing effective visual materials that achieve their goals by not only by fulfilling the functional requirements, but also by eliciting desired emotional responses from the users.

Methods

Several methods were used to develop the PPO guidelines:

- A comprehensive literature review and an environmental scan to identify best practices applicable to developing chemotherapy PPOs.
- Analyses of field study observations and incident reports to identify potential issues associated with PPOs.
- Critical review of evidence from the literature and the field study observation analyses to inform the development of a set of PPO content and design guidelines.
- Review of the draft guidelines by a clinical advisory group.
- Collaboration with graphic designers to develop sample PPOs, refine the design guidelines, and format the resulting content.

Literature Review and Environmental Scan

Multiple search strategies were used to capture articles relevant to PPOs in chemotherapy and in general medicine, as well as articles about form design in general. Journal databases searched included Ovid MEDLINE, Ovid HealthSTAR, all EBM reviews, EMBASE, CINAHL, IngentaConnect, and Engineering Village 2. In addition, Web sites of key medication safety organizations and the Internet in general were searched for articles related to PPOs and standard order sets. A total of 45 relevant articles were identified (see the Data Supplement for further details).

Field Study Observations Analysis

Workflows of PPO users (ie, pharmacists, pharmacy technicians, nurses, physicians, and administrative staff) and chemotherapy order communication processes were analyzed by developing an order information flow map for each cancer care facility studied. In addition, a human factors professional evaluated sample PPOs from the field study sites with regard to their usability and utility. Whenever available, incident reports

related to the use of PPOs were analyzed in the context of each field study site's workflows and communication processes. Finally, potential PPO issues identified were analyzed in the context of other patient safety risks identified.

Formation and Review of PPO Guidelines

The issues and best practices related to PPOs identified from the literature review, the environmental scan, and the field study observation analyses were translated into a set of guidelines by a human factors professional. A total of 64 guidelines were established in two categories: (1) 36 content guidelines and (2) 28 design guidelines (ie, format, layout, use of graphical elements, use of color, ordering of information, etc). For each of the guidelines, benefits, purposes, implementation examples (if any), human factors issues, and implementation challenges were identified. Guidelines developed on the basis of existing literature that conflicted with human factors principles and/or with the field study observations, as well as guidelines that conflicted with each other, were noted and documented.

A clinical advisory group of three oncology pharmacists, one nurse, two medical oncologists, and one radiation oncologist from six Canadian provinces was assembled to review the draft guidelines. The review process involved an online survey and two focus group sessions moderated by two human factors professionals. The survey was conducted before the focus group sessions to facilitate discussions during the sessions. The objective of the focus groups was to achieve a unanimous decision for each draft guideline. As a result, 15 guidelines were rejected, 31 guidelines were approved with revisions or conditions, and 18 recommendations were approved without revisions.

Collaboration With Graphic Designers to Develop Sample PPOs and Refine Design Guidelines

The study investigators recognized that key components of the design of PPOs were page layout, typography, and visual relationships, in which graphic designers are experts. Seven senior graphic design students and two faculty members from the Ontario College of Art and Design University in Toronto, Canada, were recruited to develop PPOs for three commonly used chemotherapy protocols. The interdisciplinary group of human factors professionals, graphic designers, and oncology clinicians used a user-centered design (UCD) method involving five iterations of identifying user requirements, designing and prototyping, and evaluating. During each iteration, the graphic designers generated redesign ideas and developed PPO prototypes, which were evaluated by the human factors professionals and the clinical advisory group via a focus group session. In the fourth iteration, 20 PPO users from across Canada participated in a user review of the PPO prototypes. During the user review, oncologists were asked to complete orders using the PPO prototypes for a set of realistic clinical scenarios provided. Then, the completed PPOs were sent to nurses, pharmacists, and administrative staff for their review. The fifth iteration included updating the guidelines on the basis of the Institute for Safe Medication Practices' newly published guidelines for standard

Table 1. High-Priority Design Guidelines

Topic	Recommendations
Content organization	<p>Each PPO must be designed and used for a single cycle only.</p> <p>Contents of PPOs must be clearly divided into logical sections with headings.</p> <p>Within each section, medication orders must be shown in the sequence of their administration.</p> <p>Chemotherapy agents must not be listed vertically with boxes or spaces to tick without a sufficient space separating one medication from another. In particular, look-alike chemotherapy medication names must not be shown near each other whenever possible.</p>
Page layout and formatting	<p>Separate lines/entries must be used for each medication order. Multiple orders must not appear on one line or within a single entry.</p> <p>Enough page margins must be left for PPOs to be properly bound and stored following the organization's policies.</p>
Use of checkmarks and checkboxes	All the items in a list using a checkmark as a bullet must not require prescribers' interventions. If an item in a list of orders must require prescribers to select from choices, those choices should be shown vertically using checkboxes and "or" in between the choices.
User-entry fields	<p>Sufficient space must be allocated around user-entry fields. If there is not enough vertical space above and below the user entry fields, the user can write on top of the text near the field.</p> <p>Size of answer spaces must align with the size of expected answers.</p>
Typography	<p>Typefaces used on PPOs must be sans-serif with regular weights and neither expanded nor condensed.</p> <p>Typefaces used on PPOs must have an x-height of no less than 1.8 mm.</p>
Use of lines	If PPOs are faxed, scanned, or photocopied, solid dark underlines must not be used to indicate user-entry fields. Dotted gray underlines should be used instead.
Printing	<p>PPOs must be printed on white or very lightly colored paper with black text. When non-white paper is used, ensure that paper color does not get transferred when it is photocopied, faxed, or scanned.</p> <p>Information must not be printed on the back side of PPOs.</p>
Other design guidelines	Adequate space must be provided between the medication name and dose, and between the numerical dose and unit of measure.
Change orders	<p>PPOs must be designed such that any change made to the standard/initial order is clearly documented with (A) reason for the change, (B) date the change was made, and (C) clinician who authorized the change.</p> <p>PPOs must allow users to easily keep track of treatment schedule changes by having the following information in close proximity to a space for each planned administration date: (A) an option for delaying a treatment day with a prompt for indicating the number of weeks of delay, (B) space for indicating the reason for the delay, (C) date the delay was ordered, and (D) initials of the prescriber.</p> <p>PPOs must allow prescribers to adjust chemotherapy medication doses.</p> <p>Sufficient space must be allocated for prescribers to make comments in a manner that other clinicians can easily identify and understand.</p> <p>Space must be allocated for adding at least one nonstandard requirement for proceeding with the treatment.</p> <p>If a PPO includes standardized laboratory orders, space must be allocated for adding at least one nonstandard laboratory order.</p> <p>Each organization must develop appropriate policies and procedures for ordering a treatment plan that consists of a nonstandard combination of chemotherapy medication orders.</p>

Abbreviation: PPO, preprinted order.

munication tools. One cancer care facility is currently using the guidelines to develop its electronic order forms. One provincial cancer agency indicated that it plans to use the PPO guidelines to develop its provincial CPOE system.

Discussion

Collaboration of human factors professionals, graphic designers, and oncology clinicians resulted in a set of 80 guidelines for developing ambulatory chemotherapy PPOs that are easy to use and able to accommodate dynamic ambulatory chemotherapy orders. The effective involvement of the two disciplines, human factors and graphic design, was pivotal to the successful outcomes of this study.

The human factors professionals' contributions to the ethnographic study and systematic risk analysis were instrumental to the PPO guideline development in a number of ways. First, they identified the need for PPO development guidelines in the cancer care community. Second, they identified that most Ca-

nadian cancer care providers, including some that have implemented a CPOE system, struggle to meet their ordering communication needs with PPOs every day; however, paper order forms have received relatively little attention compared with that given to CPOE systems in the field of patient safety. Finally, the risk analysis determined that the patient safety risks resulting from poorly designed PPOs are too significant to be left unaddressed, and the assumption that implementing a CPOE system will eliminate all these risks did not appear to be valid.

In addition, the human factors professionals applied their knowledge of human errors and a systematic understanding of chemotherapy order communication gained from the ethnographic observations to establish the PPO guidelines. Furthermore, they used several UCD methods to solicit user feedback, which they critically analyzed to identify underlying user needs.

Designing a form that is easy to use, minimizes human errors, and communicates such complex information as a chemo-

therapy order for multiple types of health care professionals who are pressured for time and frequently interrupted, as well as accommodating dynamic patient needs, is no small feat. This challenge is illustrated by the 80 PPO content and design guidelines in the *Guidelines for Developing Ambulatory Chemotherapy Preprinted Orders*.²⁴ Designing such a set of PPOs demands specialized design skills that go beyond the general design skills of human factors professionals, let alone those of health care professionals.

The graphic designers' expertise facilitated the production of a set of PPOs and a guidance document that are sensitive to user experience and that adhere to the functional requirements defined by the human factors professionals and clinicians. The results are sample PPOs and a guideline document that provide a more pleasant user experience in comparison to existing PPOs and guidelines in healthcare. Currently, health care professionals such as physicians or pharmacists without any design background are primarily responsible for developing PPOs. This was the case in all the six cancer centers observed during the study. As a result, existing PPOs may meet the functional requirements of each cancer care provider, but their successful use requires users to be always consistent, focused, and meticulous; in other words, users should be at an ideal performance level, which is almost never the case. Similarly, most of the existing guidance documents in health care rarely involve input from designers. Therefore, although technically complete and accurate, these documents tend to be difficult to follow and apply, although there are exceptions.²⁵

Although not formally tested in this study, the multidisciplinary UCD approach proposed in this article to support PPO design is also likely to support the development of computerized order sets. While the communication medium is different, many of the requirements of well-designed computerized order sets—compatibility with the organization's unique workflows, processes, and culture—overlap with those of well-designed PPOs. The UCD approach is a classic human factors design method that aims to ensure that the resulting design meets the user's needs and is highly adaptable.²⁶ The Design Process section of the guideline document describes how clinicians, human factors professionals, and designers can work together using an iterative UCD method. Any organization attempting to design standardized order sets, whether they are paper based or computerized, would benefit from this approach.

Health care is a safety-critical, dynamic, and complex socio-technical system. Identifying safety risks in a complex system and effectively addressing them often requires the expertise of multiple disciplines. This study illustrates how human factors professionals, clinicians, and designers can leverage each other's

expertise to uncover commonly overlooked patient safety hazards and to provide health care professionals with innovative, practical, user-centered tools to minimize those hazards. Given the versatility of human factors and diversity of design disciplines, this multidisciplinary approach to optimize form design for patient safety can readily be applied to many other clinical processes.

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