A Collaborative Clinical Trial Protocol Writing System

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Abstract

Increasing complexity in medicine has caused clinical trial experts with disparate backgrounds from multiple organizations to collaborate when developing clinical trial protocols. Although many protocol-authoring tools provide computer-based decision support to assist in protocol writing, few of them provide sufficient collaboration support for a group of protocol writers. The iterative group writing activities among interdisciplinary clinical trial experts call for advanced tool support. Here we present a web-based protocol writing system with integrated support for collaborative reviewing and collaborative editing. The system uses a shared database to store threaded review comments and version information for electronic protocols. It also captures rich group event information to provide cross-activity awareness and to facilitate self-coordination within the collaborative writing team. We believe that our system can help streamline collaborative clinical trial protocol writing processes.

Keywords

Internet, Clinical Protocols, Interdisciplinary Communication, Cooperative Behavior, Awareness

Introduction

High-quality clinical trial protocols, widely utilized in medical research, are critical to conducting safe clinical trials and enabling cost-effective health care. However, many existing clinical trial protocols contain problems such as incompleteness, ambiguity, and inconsistency.[1] Most of the errors are introduced during the protocol writing process, which is often inefficient. Recent studies have shown that protocol development is a collaborative scientific writing process to achieve consensus within a group of interdisciplinary clinical trial experts.[2][3][4] It is an *intellectual and creative* group task involving clinical experts, statisticians, protocol editors, and regulatory affair officers.[3]

Much prior medical informatics research has been done to assist in the protocol-writing task. The major efforts fall into the following three categories: 1) Using computational model-based decision support tools to guide clinical protocol authoring, such as *PROforma* [5], *Design a Trial* (DaT) [6], and *EON* [7] 2) Using mark-up languages or models to transfer existing free text clinical protocols into a computer-interpretable format and provide critiques to the protocol content, such as GEM [8] and DeGel [9] 3) Using a knowledge management approach to provide a structured document model or reusable text to facilitate knowledge reuse in clinical trial design, such as WITH [10]. These tools facilitate the automation, standardization, and dissemination of clinical protocol knowledge; but they have varied limitations. First, most of them are designed for a single author and do not support collaborative writing activities such as group discussions, group coordination, or version control. Second, their interfaces are often driven by rigorous computable models and are not intuitive to clinical trial experts; this necessitates assistance from knowledge engineers, who might complicate the authoring process. Third, they do not support the interactive and expressive communications required by any group-writing task, which is characterized by a high degree of ambiguity and the lack of a fixed goal.[11] Therefore, existing medical informatics tools for protocol writing mainly support human-computer interactions but ignore the aspect of human-human interactions among multiple writers.

Although many collaborative writing systems are available in the field of Computer-Supported Cooperative Work (CSCW) such as Quilt [12] and PREP [13], none of them have been adopted in group writing of clinical trial protocols. Most protocol writers rely on standard word processors and email systems to collaborate on protocol writing.[3] One possible reason is that out-of-the-box systems cannot fit into the complex workflow of the collaborative protocol writing process.

Therefore, our approach to protocol writing support is to augment the natural collaborative protocol writing process and facilitate better interactions and more expressive communications among protocol writers. Aiming at improving the quality of the resulting clinical trial protocols, we try to encourage human-centered quality control for clinical protocols by supporting multidisciplinary human clinical trial experts in iterative and collaborative protocol reviewing and revising activities, instead of relying on computer-based critiquing mechanisms. In this paper, we present an asynchronous collaborative protocol writing system that can be directly used by multiple protocol writers as a group. The asynchronous working mode is the most suitable option for clinical trial experts, who often have varied schedules. Below we first present our design methodology, including our ethnographic study methods and

participatory design process. Then we describe the system framework, the underlying comment model, our version control mechanism, the user interface, and our formative evaluation results. Finally, we provide a summary and discussion.

Methods

System Requirements Analysis

To better understand the precise tool support needs of collaborative protocol writers, we conducted an ethnographic study at the Southwest Oncology Group (SWOG), a major adult cooperative cancer research group funded by the NCI. Our detailed study results are presented in a separate paper; [3] here are the major identified problems that call for collaboration support:

- Ineffective and iterative reviewing and revising
- Poor version control for evolving protocol drafts
- Challenging integration of heterogeneous input
- Insufficient feedback and awareness of group activities
- Inefficient group coordination

All of the above problems highlight a lack of awareness within collaborative writing groups. *"Awareness is an understanding of the activities of others. Awareness of individual and group activities is critical to successful collaboration and is commonly supported in CSCW systems by active information generation mechanisms separate from the shared workspace."* [14] Awareness happens naturally in the shared workspace; therefore, users do not need methods such as email or phone calls to notify each other explicitly. In particular, we consider cross-activity awareness missing in the current protocol writing process. Cross-activity awareness is a type of awareness among collaborative writers engaged in various writing activities. For example, cross-activity awareness enables reviewers to understand the follow-up status of their comments as well as how their comments are incorporated into the new versions of the protocol; it also enables protocol editors to get immediate feedback for their writings.

Considering the above problems, we have designed a web-based collaborative protocol writing system with integrated version control for both protocol review comments and protocols. Our design goals include: 1) to enable smooth collaborative protocol reviewing and editing workflow; 2) to facilitate comment-centered in situ group discussions; and 3) to enable progress tracking for protocol development. We choose to build a web-based system for two reasons. First, it is easier to prototype and to deploy than stand alone applications. Second, it has good accessibility so that users can access it from anywhere and at any time.

Participatory Design

To ensure a close fit into clinical trial protocol writers' daily work practice, we use a hybrid participatory design approach.[15][16] We organize a participatory design team including three protocol writers, each person representing a different role in the collaborative writing process, and conduct formative user evaluations throughout the whole design process. We incrementally prototype the system and increase its fidelity. We present the prototypes to users, elicit their feedback, and incorporate their feedback into the next design cycle. We begin the iterative design with paper-based scenarios. For each scenario, we perform a cognitive walkthrough for our users.[17] The users could walk through the actions for each task and evaluate the system usability at a fine granularity level from an early stage and at no development cost. We then build the real system based on the feedback for the scenarios. Our users have had active participation in the development process and provided timely feedback with fine details in each phase of the design. This greatly ensures the usability of the resulting system.

Results

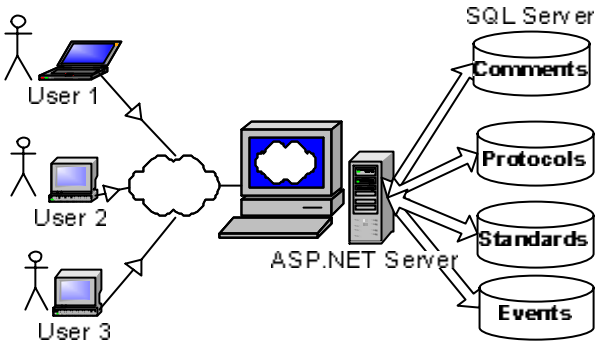

Figure 1. System Framework

Figure 1 shows the framework of our web-based asynchronous collaborative writing system, which integrates these major modules:

- Electronic protocol management with version control
- Collaborative annotation and group discussion support
- Online protocol editing support by a rich-text web editor
- Group and shared workspace awareness support
- User access management for versioned protocols

Protocol writers can access the protocol server through the Internet using browsers. The web server is built on Windows .NET server and is connected to an SQL server database. The database stores protocol chunks, comments and their responses, version information for protocols, and user activities. Typically there are three roles in a collaborative writing process: 1) the ***author***, who gets credit for the protocol design by contributing research ideas 2) the ***reviewer***, who adds comments to protocols 3) the ***editor***, who manages protocol drafts by integrating scattered inputs into a coherent document following a certain format. In SWOG, each team has only one protocol editor. All above roles are termed writers. Our system also supports a fourth role, a protocol ***manager***, who monitors the schedule and progress of the protocol development. Table 1 shows the system functionalities for each role.

Table 1. Roles and Associated Activities In the Collaborative Writing Process

Collaborative Writing Activities Roles→	Editor	Author	Reviewer	Manager
Create a new protocol: Use templates and reusable standards to create a protocol.	X			
Edit a Protocol section: Change the content of a section with an exclusive lock.	X	X		
Review a Protocol: Add in-text annotations or reply to existing annotations.	X	X	X	
User Management: User access control and user profile configuration.				X
Track Protocol Review Progress: Browse the status of each comment, related discussions on the comment, and unresolved comments for the current version.	X	X	X	X
Track Protocol Version History: Track the evolving protocol and its evolving sections and their version history.	X	X	X	X

A Comment Model and Awareness Support

Protocol review comments and version history are important information communicated within the collaborative writing group. In the current work practice, reviewers use emails to send out comments, which are detached from protocols; but they do not get timely feedback for the status of each comment. They do not know whether or not the comments have been incorporated into new versions. Reviewers have to carefully compare old versions and new versions to find differences. This process tends to be arduous and troublesome.

To solve these problems, we present a comment model with a life cycle of four statuses: 1) ***Unread*** 2) ***Responded to*** 3) ***Incorporated*** into the new version, and 4) ***Resolved***. An editor can change the status of a comment when he or she revises the protocol. The comment model contains rich information about protocol reviewing activities, such as the comment-maker, comment-responder, commenting-time, comment priority category, protocol context information, and protocol version information. When a reviewer makes a comment, he can also identify a group of protocol writers whom he wants to read or respond to the comment. Once these people are selected, they will be notified that a new comment is awaiting them for processing by email or when they log into the system.

This comment model helps us provide "design rationale" to collaborative writers and helps them understand the co-evolving process of group communications and the shared document. They can make better sense of how the shared document is modified and how a coauthor's opinions are incorporated into a document's new versions. Also, the rich information of group activities is very useful for group awareness support. Once comments are created or responded to, the protocol writers receive notification. When new versions are generated, protocol reviewers are notified of the changes as well as the causal relationships between comments that are incorporated and the changes that have been made. In addition, the web-based protocol workspace provides shared feedback for group activities and document progress. Protocol writers using this system will use less time to understand the context of their work. The group activity information is also used to form the progress tracking report of the protocol. A protocol manager can browse the version history and the status of comments at any time during the protocol development process.

Version Control and Concurrency Control

SWOG was accustomed to having only one editor in each writing group.[3] After seeing our earlier prototypes, they showed interest in a more collaborative editing mode. They suggested allowing authors to edit different parts of a protocol concurrently. Based on this request, we provide an enhanced version control at two levels: one is at the section level, and the other is at the document level. Each protocol has a complex version history tree; authors and editors can navigate through the tree to retrieve old versions for sections or a complete protocol. The authors perform version control for sections. The editor in a group is allowed to collect heterogeneous inputs from reviewers and authors, compose them into a coherent draft, and publish a new version at both levels. In addition, for each section, authors can save their writings to either the shared copy or a private copy. For each version, we use explicit lock to avoid overwriting activities.

User Interfaces

Examples of our user interfaces are shown in Figure 2 and Figure 3 on page 4. As shown in Figure 2, when a reviewer wants to add a comment, he or she can simply use the mouse to select some text in the protocol, right click the mouse button, and select "Add an annotation" from the popup menu. Then a dialog will pop up with populated anchor information as the selected text. The reviewer only needs to type a comment, select a category, and indicate who should be notified. Compared to current work practice where specifying the context of a comment is by tediously typing locations such as "section 2, paragraph 1, line 6,…" our system provides an easier method, much to the relief of reviewers. Moreover, all the online writers can immediately see highlighted in-text annotations in different colors, each color indicating a reviewer. If the writer selects to revise the content, he or she can edit a specific section or pinpoint a certain part of the protocol with a specific comment. Revisions will be done in a rich text web editor (Figure 3). To help writers share group information, we also open a small floating monitoring window to display recent activities in the writing group, as shown in Figure 2.

Status and Evaluation

The SWOG researchers who participated in our informal user

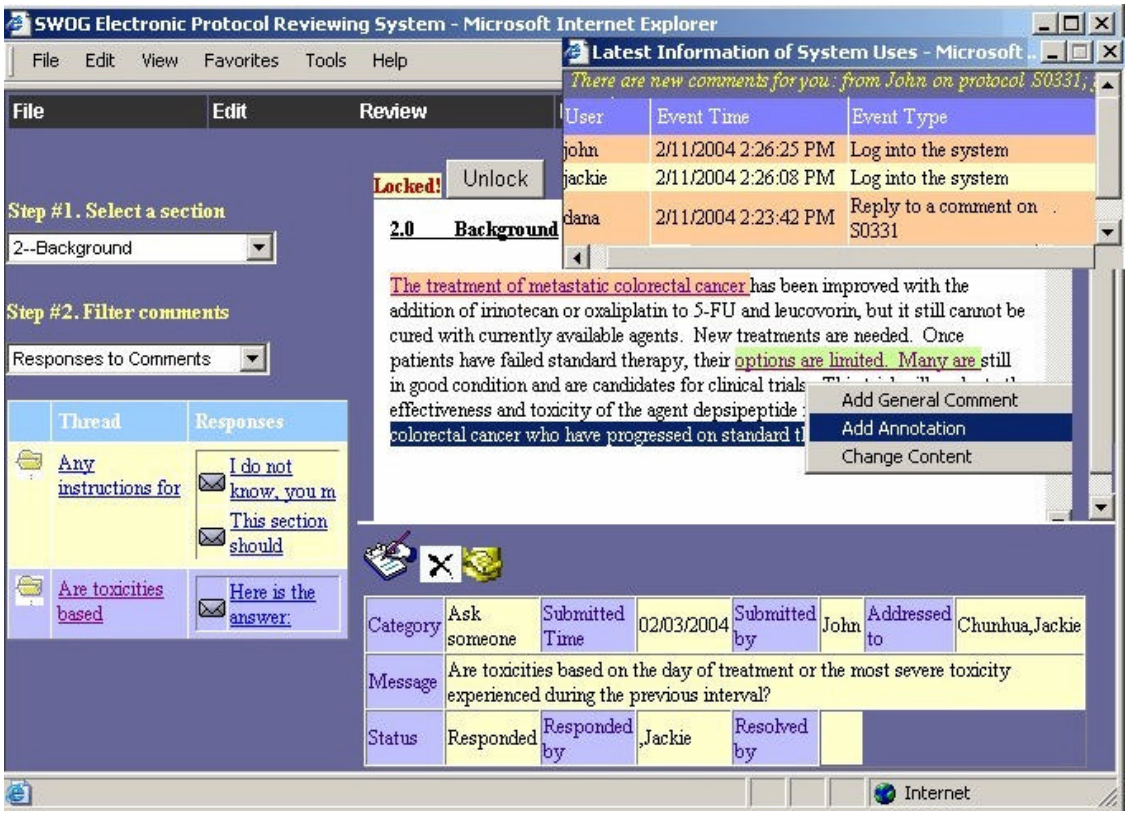

Figure 2: Collaborative Protocol Reviewing

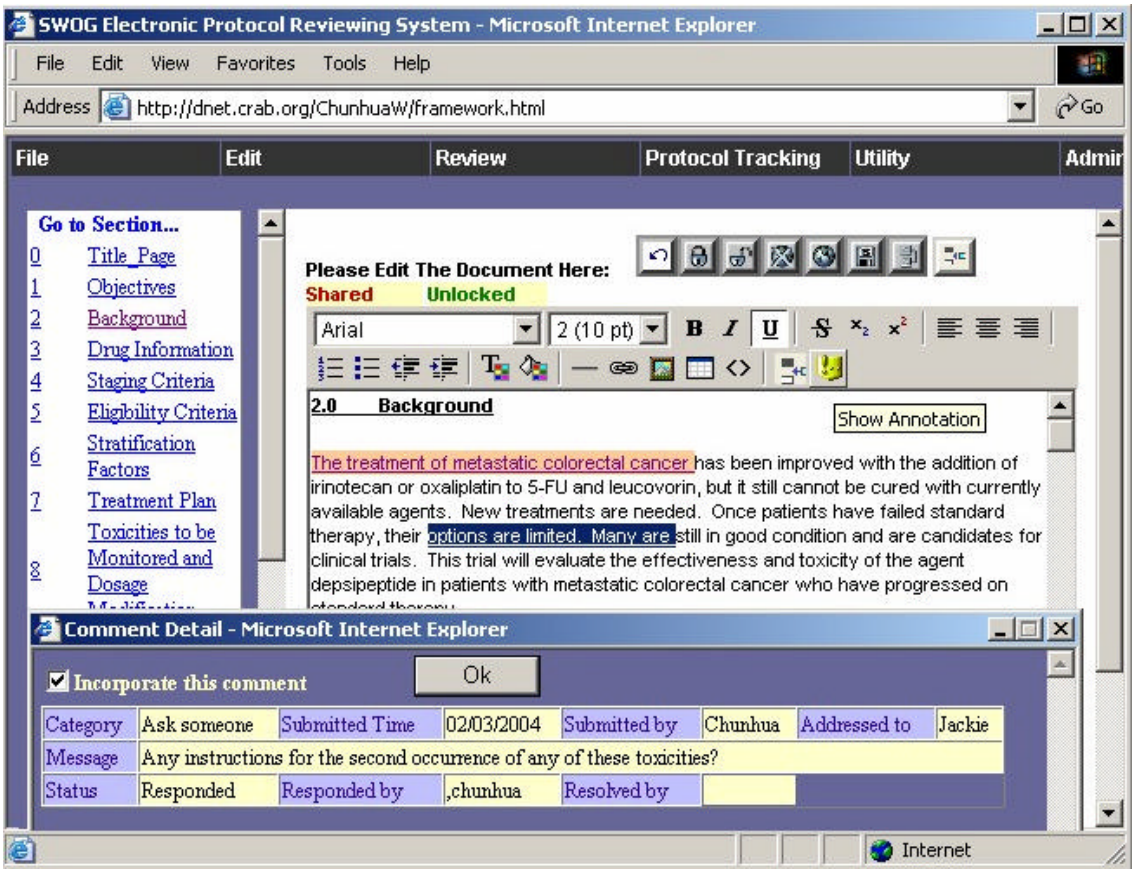

Figure 3 Collaborative Protocol Revising

studies of the prototype have given us positive feedback and showed enthusiastic acceptance of our system. Our next step is to have a field trial of the system at SWOG, test its usability and efficiency, and assess whether it can augment the real work process of collaborative clinical protocol writers. Our further evaluation goal is threefold. We will evaluate 1) whether the system is generalizable to other cooperative protocol development groups, 2) whether collaboration support among human experts is more efficient than traditional computer-based decision support tools for clinical trial design, and 3) whether this system is generalizable to other collaborative clinical document writing activities.

Summary and Discussion

We have described a web-based collaborative protocol writing system. The system design is based on a thorough understanding of the complex workflow in SWOG. Our system maintains old work practices but also encourages new collaborative work practice. We expect to see the following advantages of this system in future evaluation studies. First, reviewers will make comments directly in the context of clinical protocols and simplify the editorial process. Second, protocol document reviewing and revising activities will be seamlessly intertwined to each other. Third, interactions among group writers with disparate expertise or responsibilities will be more efficient. We hope this system can also be generalizable to other document writing activities. Moreover, we hope that our experiences from this exploratory work can help us derive better ideas to achieve collaborative information integration through annotations in dynamic collaborations. In the future, we also hope this system can be integrated into existing decision support tools for clinical trial design thereby achieving a super tool that can assist protocol writers in both "human-computer interaction" and "human-human interaction" in clinical trial design.

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