Clinical Social Networking—A New Revolution in Provider Communication and Delivery of Clinical Information across Providers of Care?

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Abstract The adoption of social media technologies appears to enhance clinical outcomes through improved communications as reported by Bacigalupe (Fam Syst Heal 29(1):1-14, 2011). The ability of providers to more effectively, directly, and rapidly communicate among themselves as well as with patients should strengthen collaboration and treatment as reported by Bacigalupe (Fam Syst Heal 29(1):1-14, 2011). This paper is a case study in one organization's development of an internally designed and developed social technology solution termed “Unite.” The Unite system combines social technologies' features including push notifications, messaging, community groups, and user lists with clinical workflow and applications to construct dynamic provider networks, simplify communications, and facilitate clinical workflow optimization. Modeling Unite as a social technology may ease adoption barriers. Developing a social network that is integrated with healthcare information systems in the clinical space opens the doors to capturing and studying the way in which providers communicate. The Unite system appears to have the potential to breaking down existing communication paradigms. With Unite, a rich set of usage data tied to clinical events may unravel alternative networks that can be leveraged to advance patient care.

Keywords Clinical information systems · Clinical workflow · Communication · Decision support · Data mining · Information visualization · Social networking · Big data

Background

The adoption of social media technologies appears to enhance clinical outcomes through improved communications [1]. The ability of providers to more effectively, directly, and rapidly communicate among themselves as well as with patients should strengthen collaboration and treatment [1]. Prior research has shown the largest share of the health information “pathology” is contained within healthcare communications [2]. Social media is transforming how individuals communicate and is often referred to as the great information equalizer [3]. Recent research suggests the use of social media as a communication tool may have additional benefits beyond communication such as aiding in the adoption of electronic medical records by physicians working in smaller practices [4]. Access to credible and relevant health information coupled with access to information and communication technology is an essential component for improving public health delivery and outcomes across the world [3, 5–7].

Communications in a hospital setting can be burdensome because communication patterns typically create an event-driven workplace [8]. Often times, resources are wasted trying to locate and contact key individuals when providing care. Some estimate that up to 55 % of the provider's day is spent communicating and collaborating [9]. Communication inefficiencies are a result of clinical tasks that generate a multitude of communication requests [2] and outdated technologies such as pagers [9]. In the clinical setting, relationships between providers are critical for the betterment of patient care. The ability for individuals to quickly identify relevant providers with respect to the patient encounter appears to be a common need across healthcare settings. Potential limitations of traditional forms of communication including telephone, email, and text paging include (1) lack of

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auditing—manual entry is performed to document communication, (2) lack of follow-up—email or text pages are easy to ignore, (3) lack of awareness—it is not easy to determine if the other person is available, and (4) lack of ownership—the message might be ignored if the receiver is not the appropriate individual to respond. The breakdown of this communication results in delays in clinical care [10]. Social technologies would, however, appear to positively impact these limitations by advancing the capacity of the users to inform and foster transparency, openness, and communications [1]. Overcoming these limitations could strengthen collaboration in the clinical setting [1].

When developing information systems, an aspect of system design that can often be overlooked is the importance of informal interactions [2]. Quite often, information comes in the form of informal communication between providers. These informal interactions may be conducted outside of existing information systems and are therefore not captured, resulting in a missed opportunity to capture data. Studies have found that face-to-face or verbal communication between colleagues fulfill 50 % or more of the overall information requests over finding the information within systems [2, 11–13]. This web of conversations that link individuals and actions comprises one of the biggest and largely untapped health information repositories available [2]. Supporting both formal and informal provider communication can improve the way in which healthcare organizations acquire, represent, and use information [2]. System designers can unlock this largely untapped repository of information by accounting for these informal interactions within system designs.

Social technologies appear to be capable of eliminating existing financial, geographical, and logistical barriers that inhibit information transparency, collaborative learning, and regular interactions among individuals where such barriers exist [1]. In healthcare, these barriers may arise in Telemedicine, eHealth, mHealth, or other clinical situations where care providers are not collocated. Examples of social technologies include “Social Networking” sites such as Facebook, Google+, LinkedIn, and Twitter. These technologies are integrated social networking technologies that are often times used to facilitate communication and collaboration between geographically dispersed users on different time schedules [1]. The term “Social Networking” commonly suggests the formation of relationships which is not a primary goal of many users of these technologies [14]. Therefore, the term “Social Technologies” will be used throughout this paper to distinguish the difference between networking activities and utilization of the technologies [14].

A common aspect that most social technologies share is a particular representation of the individual’s broader interests as a set of keywords and phrases [15]. The individual’s interest and cultural identities can be derived at a higher level by the categorical representation of these keywords and phrases [15].

Every social network has its own particular idiosyncratic representations of these concepts [15]. Some web-based social technologies allow individuals to (1) construct public or semi-public profiles within a bounded system, (2) manage and present lists of user connections, and (3) search both their own as well as other connection graphs [14]. The ability to publicly display connections and the ability to search the connection graph appears to be a crucial component of social networks [14]. Often times, social network users are not seeking relationships with total strangers but are attempting to connect with individuals that share an offline connection [14]. These connections are made between individuals who have pre-existing *latent ties* [16] to each other outside of the social technology itself [14]. Other common functionality includes the ability to send private messages or public comments on the connections profile.

Evaluation

This paper is a case study in one organization’s development of an internally designed and developed social technology solution termed “Unite.” The organization studied consists of 20 hospitals distributed across geographical areas contained within a 125-mile radius. The Unite system combines social technologies features including push notifications, messaging, community groups, and user lists with clinical workflow and applications to construct dynamic provider networks, simplify communications, and facilitate clinical workflow optimization. This system was designed as an extensible platform consisting of both standalone applications and widgets that can be embedded within existing clinical applications on a variety of platforms including Windows, Apple iOS (iPhone, iPad), and Android.

Unite was designed to close the gap in existing communication processes and systems. Current communication systems include a variety of email, phone, text pager, overhead pager, instant messaging, and custom-developed software as well as a multitude of in-person communication processes. Each existing system evolved to solve a specific need (e.g., radiologist/emergency room communication), but does not address the overall role of that communication in the larger patient context. For instance, communication between a radiology resident and her/his attending might also be valuable to the radiology technologist, nurse, or emergency room physician. Additional issues arise depending on technology or communication mode selection. In-person communications are not traceable while pager communications do not force a closed-loop process. The scope of the Unite project intended to connect everyone that participates in the care of a specific patient from the onset. These participants were categorized into four groups (Table 1) which are graphically pre-presented in Fig. 1. The four groups include internal clinical, external clinical, internal non-

Table 1 Unite user groups

Group	Internal or external	Clinical or non-clinical	Participants
1	Internal	Clinical	<ul style="list-style-type: none"> • Attendings, fellows, residents • Nurses, technologists, medical assistants • Registration, Scheduling, Transcription
2	External	Clinical	<ul style="list-style-type: none"> • Referring clinicians, telemedicine, remote consults
3	Internal	Non-Clinical	<ul style="list-style-type: none"> • Help desk, analysts, software engineers • Administrators, security, legal
4	External	Non-Clinical	<ul style="list-style-type: none"> • Patients, caretakers, legal guardians

clinical, and external non-clinical. Technology platforms used by each group are also listed in Fig. 1. These platforms include Windows, Apple iOS, and Android.

Informal cognitive interviews with participants were conducted over the course of 3 months. The participant group included a total of 13 individuals spread across seven specialties including Critical Care, Emergency Medicine, Hospitalist Medicine, Neurology, Radiology, Pathology, and Anesthesia. The primary focus of the Unite pilot was on members of group 1, internal clinical users, with attention being paid to group 2, external clinical users. The participant list is shown in Table 2. Each participant interview lasted approximately 60 min, and some participants were interviewed multiple times. The initial Unite concept grew out of an existing communication problem in radiology which explains the heavy involvement of the Medical Director of Radiology Informatics.

Content analysis of the interview data revealed a common theme across the provider community which includes physicians, nurses, pharmacists, technologists, and medical assistants among other individuals. All individuals agreed that valuable time is wasted attempting to identify, locate, and contact each other. Additionally, existing communication tools such as instant messaging, text paging, and phone calls can be effective for care collaboration if the individual knows (1) who they wish to contact and (2) the preferred or optimal mode of communication (e.g., phone call, text page, overhead, page, instant message, email, etc.).

Theme 1: Time is wasted attempting to identify appropriate providers when caring for a patient.

Theme 2: Time is wasted using sub-optimal communication channels with providers when caring for a patient.

Additional frustration appeared to result from the lack of a feedback loop from recipient to the sender. Participants identified the inability to know if the message was not received or simply ignored by the recipient. All participants identified the need for a closed-loop messaging system.

Theme 3: Time is wasted due to a lack of feedback from the recipient to the sender.

Significant quotes identified during content analysis are identified in Table 3. A total of six use cases (Table 4) were identified through the course of the cognitive interview process. These use cases spanned clinical specialties but followed a similar pattern where users reviewed information systems, attempted to determine the appropriate individual to communicate with based on the available information, and then attempted to locate the particular individuals.

Requirements for the Unite system were derived by applying concepts from the social technology paradigm to

Fig. 1 Unite user groups

Table 2 Participant list

Title	Specialty	Interviews
Chief medical information officer	Critical care	1
Chief medical officer	Emergency medicine	1
Physician	Emergency medicine	1
Physician	Hospitalist medicine	3
Physician	Hospitalist medicine	1
Chief medical information officer	Neurology	5
Medical director radiology informatics	Radiology	7
Vice-chair radiology	Radiology	1
Nurse	Radiology	1
Medical director pathology informatics	Pathology	1
Associate director pathology informatics	Pathology	1
Resident	Pathology	2
Physician	Pediatric anesthesia	1

problems associated with existing systems. Functionality such as asynchronous messaging, presence, and directory information predate social technologies and do not provide a unique experience by themselves. The application of these concepts to a particular social community based on the communities' needs provides the unique experience. This is evident by the difference in application by Facebook, Twitter, and LinkedIn which result in different user experience. Applying the healthcare lens to the social technology paradigm to the requirements resulted in a different application

Table 3 Significant quotes per theme

Theme	Quote
1	"I know a resident is involved, but I don't know which resident"
1	"The attending in the system isn't always the provider caring for the patient"
1	"The director number is the physician office... I need to know where they are at on the floor"
2	"I'm always interrupted at the wrong time"
2	"People grab me in the hallway and I get sidetracked before I can take the appropriate action"
2	"The person on the other end of the page has no idea how busy I am at the moment"
3	"Sometimes pages never get responded and I don't know if it's a system failure, the provider is busy or I have the wrong number"
3	"I don't want to interrupt someone with an issue that can wait, but more often than not, I select the most convenient mechanism for me"
3	"I don't know if the resident is ignoring me or never received my message"

Table 4 Initial unite use cases

Actor	Description/Workflow
Hospitalists	Hospitalists require results from many different specialties before discharging a patient. Currently, hospitalists have to search multiple systems including the Hospital Information System (HIS), Radiology Information System, Cardiovascular Information System, and Laboratory Information System to determine when a report is available. Once all reports are available, the hospitalist should be notified so they can contact the floor and discharge the patient.
Anesthesiology	Anesthesiologists oftentimes have difficulty locating the hematologist. The hematologist should be notified when anesthesiology orders a quantity of blood that exceeds a threshold. The hematologist should then communicate with the anesthesiologist.
Emergency room	Emergency room physicians have difficulty locating the radiologist that is about to read a patient's exam. Radiologists tend to lock numerous cases in the PACS system and build a personal queue. The emergency room physician should be able to see which radiologist has the patient's exam locked and initiate a communication.
Outpatient clinic	Some referring clinicians prefer to wait until a report is available before allowing a patient to leave their office. The referring clinicians would like to both identify an exam as priority and receive a notification when the exam has been read.
Post report follow-up	Providers oftentimes have questions regarding a particular report. The provider would like to initiate a communication with the radiologist, but not disrupt critical workflow. The provider would like a mechanism to know if the radiologist is available and ability to send a communication request.
PIC-line notification	Nurses need a notification when the radiologist confirms the PIC-line has been appropriately placed. Nurses would like the ability to then directly contact the radiologist if they have a follow-up question.

and user experience. The specific requirements were defined by assessing the themes discovered in the cognitive interviews against communication mode influences and current communication limitations (Table 5). These requirements were then used to derive the Unite feature set (Table 6).

The feature set was analyzed and the Unite Architecture (Fig. 2) was created consisting of a multi-tiered client-server system. The basic workflow begins with events that are aggregated from Vendor and Custom systems including Hospital Information Systems (HIS), departmental information systems, and custom applications. These events include Patient Registrations, Patient Admissions, Patient Discharges, Patient Transfers, Study Orders, Study Results, as well as intermediate state changes such as physician queue locking, WET reads, and preliminary report signoffs.

Table 5 Unite requirements related to current communication drivers

Communication driver	Unite requirement
Influences on communication mode	
Synchronous bias	Asynchronous messaging
Opportunistic information seeking	Provider presence and availability
Inadequate role and responsibility directories	Up-to-date directory information
Consequence ignorance	Formalization of informal communication
Current limitation	
Lack of auditing	Fully auditable
Lack of follow-up	Closed-loop messaging
Lack of awareness	Notifications and notification monitoring
Lack of ownership	Notification escalation

Discussion

Modeling Unite as a social technology may ease adoption barriers. It is known that physicians have been utilizing social network technologies including Twitter and Facebook to friend each other for a variety of communication needs [17]. Although little is known about the way in which clinicians communicate among themselves [2]. Developing a social network that is integrated with healthcare information systems in the clinical space opens the doors to capturing and studying the way in which providers communicate. Social technologies are able to provide a rich set of naturalistic behavioral data [18]. Large-scale patterns of connection graphs and usage can be explored by network engineers once profile and linkage

data are established [18]. Provider profile data and the Provider Timelines in Unite can be the source of this profile and linkage data. Membership in accountable care communities can be inferred by tracking how providers communicate. Individual provider interests and communication needs can be determined by analyzing the types of messages sent between individuals in the context of the particular clinical event. Predictive analytics can be used to determine if additional providers need to be brought into the conversation based on the type of clinical event and the content of the discussion.

A unique feature of social technologies is their ability to make users' social networks visible to others which may enable individuals to connect [16]. In Healthcare, social technology concepts derived from social networking sites can be used to create information systems that facilitate generation of dynamic provider networks. Beyond individual preference, privacy concerns govern sharing of content in healthcare. The user cannot simply choose to share protected health information without informed consent. Unite takes the concept of network to the next level through its ability to dynamically generate provider networks and present those networks to the user in the form of *Provider Timelines* which describe the distinct individuals that have participated in the care of a patient. These patient centric networks may contain all providers involved in the care of a patient. The providers' relationship with the patient contributes to the formation of latent ties between providers which describe connections between individuals that have not yet directly associated with each other.

Unite differs from commercially available social technologies because providers are passively "friended" to each other based on their relationship with the patient. There is no formal acceptance action by the user whereas the relationship is inferred through the combination of the users' role, captured clinical workflow events (e.g., HL7 events, patient context, physician sign-out, consultation lists, etc.), and other interactions with information systems. Provider

Table 6 Unite features

Unite feature	Description
Provider timeline	A dynamic context-sensitive listing of unique providers caring for a particular patient. The Provider Timeline is the subset of providers listed in the Patient's Journal.
Provider presence	Provides a status indicator indicating whether or not a user is logged into the system, their job role, and their availability.
Patient journal	A chronological listing of relevant actions, comments, and events with respect to a patient. Users can post messages or notification requests at the patient or event level.
Provider communication	Communications is enabled within the Unite system by providing access to a dynamic up-to-date directory as well as through secure asynchronous messaging. Communications conducted through the Unite system are fully auditable.
Provider notifications	Notifications in Unite can be generated by events or subscriptions. Subscriptions are role-based to minimize noise. Event-based notifications can include one-time requests or escalation of an unacknowledged communication request.

Fig. 2 Unite architecture

relationships with patients can be extended, as in the relationship between a patient and their primary care provider, or temporary, such as the relationship between a patient and an emergency room physician. Providers may take seemingly unrelated actions that result in the action of being added to the graph. Actions such as simply opening a patient's record or viewing an image can result in being added to the graph. Unite does not allow the providers to "friend" another provider in an ad-hoc manner. Focusing provider graphs on the patient minimizes the opportunity for communication misuse. Providers can only communicate with other providers that have an active relationship with the patient of interest. Unlike other social technologies that allow users to identify their own interests, Unite focuses on the user's identity. Interests are inferred by the relationship to the patient and the current clinical situation. This representation of identity is analogous to their clinical role, e.g., attending, specialist, nurse, technologist, etc.

Unite is able to monitor and track subtle events such as opening a patient record. The event itself may be of particular interest to a provider or combined with other events to form a meta-event describing a more complex clinical situation. This information becomes part of the Patient Journal and the set of distinct providers is added to the Provider Timeline. A real-time dynamic provider graph is created and centered on the patient that exists for the lifetime of the clinical event. Unite

does not require the user to know specifically whom they wish to communicate with prior to initiating the communication. Providers can navigate the provider graph with role sensitive filters exposing only providers that are relevant to the specialty of interest in the context of a patient. The graph generated by Unite coupled with its event-processing engine allows for the generation of specific events to specific individuals. Notifications can be generated and sent when reports are filed to a set of providers on their mobile devices to expedite care or the discharge of a patient. Currently, providers frequently check a number of information systems for these reports. Unite can also aggregate and withhold notification until all critical pieces from varying systems are available. This aggregation allows for the generation a single event which minimizes noise and increases the effectiveness of the notification.

A common aspect shared across many social technologies is the ability for an individual to post, upload, or otherwise input data into the system to create their profile. This information can be shared privately among friends or publicly allowing others to find them based on a particular skill, common interest, or shared relationship. In order to be useful in medicine, this information must be accurate and relevant to the particular expertise or service delivered by the provider. As pressure increases to provide as efficiently as possible, the importance of accurate and relevant information also

increases. Therefore, more automated ways of generating content and contacts in the system is critical. On the surface, the push in medicine away from paper-based workflow to electronic systems would seem like a goldmine for creating these links. However, the types of communication that need to occur are between physicians using different systems or not using the same system at the same time. Creating these connections will require novel methods of looking at these events occurring in different silos.

Unnecessary or extra communications oftentimes occur because current systems are designed to send information in one direction. This leaves the user wondering if the request were received and if the request is being acted on in a timely manner. A key characteristic of Unite is closing the loop in information system communications. Unite has the ability to serve a wide range of healthcare communication needs including supporting efforts in healthcare information exchange. Clinical events such as abnormal lab results or report discordances can trigger automatic notifications and initiate communications between providers that would otherwise not directly interact. Unite has the capability to filter communications based on individual preference or allow for group subscription policies. Both of these features are targeted at minimizing notification noise and to increasing the likelihood that the user will react to the message. Notifications sent through and generated by Unite may include non-critical peer-to-peer messages or critical alerts such as report discordances. Another example of a non-critical alert includes notification to the emergency room physician when a radiologist locks an exam on the work queue. Prior to Unite, the emergency room physician had to wait until the study was interpreted and the report was generated to identify the radiologist providing care.

Conclusion

The Unite system is a patient centric clinical social technology that facilitates a wide variety of communication including voice, video, instant message, SMS, email, text paging, discussion boards, and web logs. The use cases reviewed suggest a wide range of possibilities and applications offered by this technology. The most important features of the Unite system appears to be the Provider Timeline supported by the Provider Presence indicator which allows users to quickly identify the correct provider and their status within the context of a patient. These features are supported by mobile device integration and timely delivery of notifications.

The Unite system appears to have the potential to breaking down existing communication paradigms. Unite seeks to promote physician mobility through the tracking and delivery of important clinical events as well as enabling communication on mobile devices. This breakdown may change the way

providers view communication in the healthcare setting, but further research is needed. One way to understand social networks is by looking at how users interact with them in terms of membership, growth, and change [19].

- **Membership.** What are the structural features that influence whether a given individual will join a particular group [19]?
- **Growth.** What are the structural features that influence whether a given group will grow significantly (i.e., gain a large net number of new members) over time [19]?
- **Change.** A given group generally exists for one or more purposes at any point in time; in our datasets, for example, groups are focused on particular “topics of interest.” How do such foci change over time and how are these changes correlated with changes in the underlying set of group members [19]?

Evaluating Unite with regards to these dimensions may not only tell us something about the patient centric communication network, but also lead us to a better understanding of the healthcare process.

System designers can utilize a wide range of interventions including (1) communication channels, (2) communication services, (3) types of messages, and (4) semi-autonomous agents in their design [2]. The Unite system utilizes all aspects of the aforementioned interventions. The Unite Core is comprised of an application server that listens, aggregates, and processes these events for the purposes of provider identification, notification, or communication. The Unite system utilizes enterprise services for Master Patient Indexing of patients and providers. The Unite system also includes a web-accessible HTML client, desktop client, iOS client, and Android client for cross-platform support.

Communication inefficiencies are compounded by system designs, technology limitations, and clinical behaviors that typically result in a greater number of communications than required [2]. Interruption leads to attention diversion, forgetfulness, and errors [2, 20–22] which is a significant concern that may result in clinical staff errors [2]. Interruptions can also increase costs and reduce efficiency resulting in rescheduling or transferring work [2]. High levels of communication patterns can be influenced in the following ways: (1) synchronous bias—favoring interruptive modes because these modes are effective, (2) opportunistic information seeking—impromptu face-to-face discussions with individuals that are difficult to schedule time with, (3) inadequate role and responsibility directories—out of date internal or external listings which becomes a complex management issue as teams of doctors cross-cover patients in the hospital setting, and (4) consequence ignorance—failure to understand the impact of the interruption [2, 23]. Unite attempts to address these inefficiencies, but further study is required to assess its impact though the analysis of provider networks.

Recent research on social technologies suggests that individual connections are not the only network worth investigating [14, 15]. Other ways in which they can be examined include tastes such as favorite music, books, film, etc. [14, 15]. These tastes or taste fabrics are alternative networks in which individuals participate [14, 15]. With Unite, a rich set of usage data tied to clinical events may unravel alternative networks that can be leveraged to advance patient care. It may be possible to determine (1) who providers communicate with most often, (2) under what clinical situations do these providers communicate, (3) what providers are on the critical communication path, and (4) what impact does latency in the communication process have on patient outcomes.

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