Yale University
EliScholar – A Digital Platform for Scholarly Publishing at Yale

Yale Medicine Thesis Digital Library

School of Medicine

January 2012

Online Communities Driving Guideline Adoption In National Health Care Initiatives: An Examination Of The Door-To-Balloon Alliance Online Community

Alexander Nazem

Follow this and additional works at: http://elischolar.library.yale.edu/ymtdl

Recommended Citation

Nazem, Alexander, "Online Communities Driving Guideline Adoption In National Health Care Initiatives: An Examination Of The Door-To-Balloon Alliance Online Community" (2012). *Yale Medicine Thesis Digital Library*. 1745.
http://elischolar.library.yale.edu/ymtdl/1745

Online Communities Driving Guideline Adoption in National Health Care Initiatives: An Examination of the Door-to-Balloon Alliance Online Community

A Thesis Submitted to the
Yale University School of Medicine
in Partial Fulfillment of the Requirements for the
Degree of Doctor of Medicine

by

Alexander Gharib Nazem

Class of 2012

This thesis is dedicated to the loving memory of my dear aunt,
Simin Gharib Naraghipour,
whose life was dedicated to building vibrant communities.

Acknowledgements

Though the name printed on this thesis is mine, truly this endeavor was the result of the hard work and support of many people and institutions. Without them, I would not have been able to achieve this important milestone.

First, I would like to thank Dr. Harlan Krumholz and Dr. Elizabeth Bradley for their patient guidance and wise insight during this research. They were and remain trusted mentors to me, and I am truly grateful for their support.

I would also like to thank the American College of Cardiology and the Door-to-Balloon Alliance team for allowing me such broad and unfettered access to them and their work. What they do is so important, and it was inspiring to get such a close look at their work.

I must also thank the Yale School of Medicine Office of Student Research for coordinating the award of grants to support my research. A substantial portion of my research was financially supported by the Richard Alan Hirshfield Memorial Fellowship and the YSM Medical Student Research Fellowship.

Most importantly, I would like to thank Dr. Ingrid Nembhard who served as my thesis advisor, but who is really so much more. She is a kind and brilliant person who pushes me to do better work. This thesis would be only a shadow of what it is without her wisdom, ideas, sharp editing, and constant consultation. But it is our

positive working relationship that I cherish most. I eagerly look forward to a career-long collaboration and more importantly to a lifelong friendship.

Finally, I want to thank my family, especially my parents and my sister, for providing unwavering support to me in my long journey through academia. It has been a joyful ride in large part because they have been by my side to share the ups and downs. This thesis is as much their accomplishment as mine.

Table of Contents

Abstract:

Research suggests that health care organizations struggle to implement evidence-based guidelines. In the wake of this observation, national quality improvement initiatives have increasingly sponsored online communities (OCs) in which organizations and professionals can seek guidance from their peers on the many challenges that accompany the shifts in practice caused by guideline adoption.

In this paper, I examine the effect of participation in an OC on hospitals' implementation of evidence-based guidelines. I hypothesize that hospitals whose staff utilize OCs are more successful at achieving guideline implementation, leading ultimately to greater clinical outcome improvement. This hypothesis was tested using data from the OC of the Door-to-Balloon Alliance (D2B), a national campaign that promoted the adoption of five evidence-based practices to reduce time to treatment in order to reduce morbidity and mortality related to ST-segment elevation myocardial infarction (STEMI). The improvement in door-to-balloon time of hospitals that participated in the OC (52%, n=378 of 731) was compared to that of hospitals that did not. There was positive correlation between OC use and door-to-balloon time improvement, however it was not statistically significant (p value>0.05).

In this paper, I review the literature on OCs and then use it to examine several potential reasons for why D2B OC use was not associated with improvement in door-to-balloon times. I conclude that the design of the D2B OC undermined its

6

effectiveness. Therefore, I suggest that OCs cannot yet be rejected as a tool to accelerate guideline adoption and clinical outcome improvement. Greater attention must be devoted to their design.

Introduction

The health care system has entered into a period of great change. In an era of rapidly increasing costs,[1] major demographic shifts,[2] a growing burden of many chronic diseases,[3,4,5] and an overall weakened economy, the health care system is, out of necessity, making significant changes to the way it delivers care to patients.

One of the significant changes over the last 20 years is the adoption and spread of evidence-based medicine (EBM). This is a style of medical practice in which there is "conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients."[6] Evidence-based medicine recognizes the role of art in medicine but aims to standardize aspects of medical care based on scientific findings. In EBM, the effectiveness of various diagnostic and therapeutic options for specific clinical scenarios are compared to determine which methods of practice lead to better health outcomes.[7] Accordingly, EBM has manifested itself in the form of clinical practice guidelines, which encourage – or even require – providers to deliver care according to current evidence-based best practices.[8]

While the concept of EBM was originally met with some resistance – many in the medical profession decried the specter of "cookbook medicine" – it has now become widely accepted.[6,8,9,10] However, while most stakeholders in health care now recognize the value of practicing EBM (i.e., higher quality care for patients), implementation of evidence-based guidelines varies widely across care settings and

across disciplines of medicine, as was thoroughly demonstrated by McGlynn and colleagues. [11] For example, there are well-established best practices for managing patients with hypertension[12] and hyperlipidemia,[13] but for both conditions, fewer than half of all patients with known disease are well controlled.[14, 15]

Evidently, changing and enforcing standards of practice is a slow process. The literature suggests that it takes an average of seventeen years for guidelines to migrate from theory to daily practice.[16] Therefore, accelerating the rate of guideline adoption remains a key challenge in medicine.

As such, the last several years have seen the proliferation of many national initiatives and campaigns to drive widespread, routine, and reliable use of evidence-based practice guidelines. Typically, these initiatives highlight a specific area of medical practice for which there is a strong evidence base for a particular approach to care but still a gap between that best practice and actual practice, implying that optimal health outcomes are not achieved. Having identified an area that could improve through the adoption of well-established practice guidelines, these initiatives use a variety of mechanisms, ranging from publicity to technical assistance, in order to focus attention and energy on the problem and ultimately to drive closure of the gap between best and actual practice.[17,18]

Some recent examples of national initiatives include the Surgical Care Improvement Project (SCIP)[19] that focused on avoiding many preventable peri- and post-operative

complications; the Institute for Healthcare Improvement's 100,000 Lives[20] and 5

Million Lives[21] campaigns, which both aimed to drive adoption of numerous

interventions to reduce inpatient morbidity and mortality; the American College of

Cardiology's Door-to-Balloon (D2B) Alliance[18, 22] that promoted practice guidelines

to shorten door-to-balloon times and thus reduce mortality for patients with ST-

segment elevation myocardial infarction (STEMI); the Home Health Quality

Improvement initiative[23] that aimed to reduce unnecessary hospitalizations; and the

just launched Department of Health and Human Services' Million Hearts Campaign

that is working to prevent morbidity and mortality associated with cardiovascular

disease.[24]

A common theme across all of these initiatives, and the many others like them is

that they are supra-institutional. That is, the call for health care institutions to

implement the evidence-based guidelines comes from a third-party organization or

consortium of organizations. This serves two purposes. First, the goal of these

initiatives is to propel widespread, often national, adoption of guidelines in order to

change standards of practice across institutions. It is therefore necessary to include

as many health care institutions as possible. Second, there is a desire for the

participating institutions to collaborate with each other on how to turn the

guidelines from recommendations into actual practice.

The latter goal of developing implementation plans is of great importance and has

proven to be one of the most difficult challenges for the evidence-based medicine

movement. Guidelines are headline recommendations that serve to set a goal, but turning those guidelines into actual practice requires detailed, institution-level strategy and logistics that national initiatives do not and cannot provide. Adopting guidelines often means considerable shifts in practice, reworking complex processes, staff reorganizations, financial investments, and a host of other significant changes for institutions. And these shifts must be uniquely adapted to the local institutional environment. Thus, guidelines only establish "what to do," but it is left to organizations to determine "how to do it."[25]

Many participants in these national initiatives encounter the same problems when implementing guidelines. This suggests that there is great potential for organizations to learn together and share relevant knowledge for communal benefit. As they seek out solutions, institutions can help each other implement EBM guidelines by sharing everything from remedies for specific problems to tools to peer-to-peer counseling and support. However, because institutions participating in national initiatives often lack formal ties and are in different geographic regions, developing cross-institutional sharing relationships and effectively creating and transferring practical knowledge are challenges in themselves.

One way to facilitate cross-institutional knowledge-sharing may be online communities (OCs), which are virtual collaborative spaces where institutions can meet to share ideas. Accordingly, OCs have become common components of national initiatives. In this paper, I explore the impact online communities can have on

national health care initiatives. I hypothesize that such virtual collaborations may accelerate guideline adoption and ultimately improve clinical outcomes by bringing together health care professionals to share their experiences and teach one another how to achieve effective guideline implementation. To test the hypothesis, I, as part of a research team, examined the relationship between the use of the D2B Alliance's online community and hospitals' performance improvement. Our team found no statistically significant relationship.

In order to interpret this finding, I review the case of the D2B Alliance online community in detail and present our team's research on how the OC was used. I then review the literature on OCs, examining the general concept of an online community and theories on how best to construct one. Then, I survey the many types of online communities, with a special emphasis on one type – a so-called community of practice, which the D2B online community was and which is particularly relevant to the needs of multi-organizational health care initiatives. Using these models derived from the literature, I examine several potential reasons for why the D2B OC use was not associated with improvement in door-to-balloon times and conclude that the design of the D2B OC undermined its effectiveness.

A Case Study: The D2B Alliance Online Community

In this section, I describe the D2B initiative and the affiliated OC. To test the hypothesis that online communities can accelerate guideline adoption, I examine the D2B Alliance using data from my own analysis as well as from a previously

published study produced by a research team of which I was a part.[26] The complete results of that study – which sought to characterize who used the community, how those users perceived the community's value, the purposes for which the community was used, and whether community participation was associated with improved outcomes – have been published elsewhere.[26] Appendix 1 contains an abbreviated description of the methods we used in that study that are relevant to this paper. In this section, I present the germane results from the published study as well as my unpublished findings.

The Initiative

The Door-to-Balloon Alliance (D2B Alliance) was a national quality improvement initiative sponsored by the American College of Cardiology and 38 other organizations that sought to improve care for patients with ST-segment elevation myocardial infarction (STEMI) through the reduction of door-to-balloon times.[18] The initiative ran from November 2006 through March 2008 and enrolled more than 1000 hospitals.[27,28] The D2B Alliance was run as a campaign that advocated for hospitals across the nation to implement five practices that were proven to reduce door-to-balloon times. The campaign supported the participating hospitals by placing educational materials on a website, hosting webinars on each of the five practices, running workshops at major conferences, distributing a newsletter, establishing a network of mentor hospitals, and launching an online community.[29]

The D2B Online Community

The D2B Alliance campaign consisted of a two part online community that went live on March 29, 2007 and received official support from the campaign through February 29, 2008. The first component of the OC was an email listserv. The second component was a web-based collaboration portal that was distinct from the D2B Alliance's main website.

The listserv operated in the standard manner, where messages sent to the listserv address were distributed to all subscribed members via email. Replying to a message received from the listserv would send the new message to all members. Messages could be sent with attached documents. Every message that passed through the listserv was automatically posted to the "Discussions" section of the web portal. However, message attachments were not archived in the "Discussions" section. Every email with a new subject line was organized, along with related replies, into threads.

Members were able to manage their subscriptions to the listserv via the web portal. They could opt to 1) receive, via email, every message as it was sent to the listserv, 2) receive a single daily digest email of all the messages (or just their subject lines) sent in one day, 3) view messages in the portal's "Discussions" section only and receive no email, or 4) unsubscribe from the community completely. The web portal offered additional collaborative tools. Beyond the listerv archive, there was a section for community announcements, a directory with contact information of community

members sorted by institution, and a document repository where members could post files directly to the portal for sharing with other portal users. The web portal was hosted by the Institute for Healthcare Improvement (IHI), so community members needed to create an account on IHI's website in order to access these features.

Of note, at the outset, online community participation was not voluntary. On the community's launch date, March 29, 2007, D2B campaign staff automatically enrolled each hospital's chosen key contact in the OC (both the listserv and the portal). They all received an email through the listserv that 1) indicated that they had been enrolled, 2) provided instructions on how to access to the web portal, and 3) provided instructions on how to invite other colleagues from their hospitals to join both components of the online community. On April 3, 2007, six days after the launch, the settings of the listserv were changed to an opt-in format, in response to complaints about the volume of email and involuntary enrollment. D2B staff sent a message to all community members explaining that if members wanted to continue receiving listserv emails, they would need to indicate that preference using the subscription management tool on the web portal.

Usage of the D2B Online Community Listserv and Web Portal

Over the course of the initiative, the D2B OC was used extensively. Nearly 52% (n=378 of 731) of hospitals participating in the initiative and in our study[26] used the online community, with use restricted almost exclusively to the listserv. In the 11

months that the OC was live and supported by the D2B campaign (March 2007 –

February 2008), 206 individuals exchanged 1155 messages in 154 unique topic

threads on the listserv.[26] One third (n=389 of 1155) of all messages were sent in the

first two months. The majority of messages (n=618 of 1155) were sent in the first

four months. Messages were sent to the listserv for a variety of purposes, as shown

in **Table 1** below.

Table 1: Purpose of Messages

Purpose of Message	Number (%) of Messages* (n=1155)
Information-sharing	657 (57%)
Information-seeking	295 (26%)
Declaring a position on an issue	137 (12%)
Expressing appreciation for information or community	72 (6%)
Handling listserv errors, system or user induced	51 (4%)
Establishing community norms for sharing and replying	37 (3%)
Planning additional activities, for example new webinars or face-to-face meetings	20 (2%)

Table adapted from Nembhard IM, Nazem AG, Webster TR, Wang Y, Krumholz HM, et al.[26]; * Total number of messages >1155 as some messages had more than one purpose.

By contrast, the web portal was sparingly used. Beyond the archive of listerv

messages, the only other portal sections used were the announcements section and

the document repository. In all, only four announcements and 76 documents were

posted, all by D2B campaign staff. None were posted by community members. The

majority (52%, n=40 of 76) of the files posted to the documents section were

generated by the D2B Alliance staff and were also available on the main campaign

website. The remaining 48% of documents posted to the portal were tools and

presentations produced by D2B campaign participants. Those tools and

presentations posted to the portal were originally shared as attachments on the

listserv, and D2B staff subsequently took care to post those attached files to the

portal. Due to the technical limitations of the portal platform, it was not possible to determine how often, if at all, the various sections of the portal were accessed by community members, but based on the fact that no campaign participants posted any documents or announcements, it appears that the web portal went almost entirely unused by members not affiliated with the campaign office. In sum, the web portal was not a site of two-way, online communication between D2B member hospitals despite its technical potential to act as such. At best, it was a one-way communication mechanism used by D2B staff.

Users of the D2B Online Community and the Community's Impact on Them

Users who contributed messages to the listerv represented many different health care disciplines.[26] Physicians comprised 8% (n=17 of 206) of all contributors. Nurses comprised 70% (n=145 of 206). Allied professionals comprised 3% (n=7 of 206). Non-clinical hospital staff comprised 3% (n=7 of 206). D2B campaign faculty and staff comprised 2% (n=5 of 206). The professions of an additional 12% (n=25 of 206) of users were unable to be identified. Notably, the rate at which these individuals contributed messages to the OC changed over time. The activity level was heavily skewed toward the first months of the OC's existence and tapered off steadily as time went on.

Overall, users seemed to find the online community to be valuable. In a survey on the helpfulness of various elements of the D2B Alliance campaign, 62% of OC users (n=185 of 299 OC participants responding to survey) rated the online community as

either "Helpful" or "Very Helpful."[29] Despite the reported helpfulness of the OC as

rated by its participants and the seemingly high level of activity in the community,

participation in the online community was not associated with statistically

significant improvement in door-to-balloon times or adoption rates of the D2B

Alliance suggested practices.[26]

Understanding the Limited Impact of the D2B Online Community

In order to understand why the D2B online community was not associated with

accelerated guideline adoption, we must first understand online communities in

general. In this section, I review research and theory on OCs in order to clarify the

notion of online communities and how to design them by discussing four prominent

models for assessing OC structure and purpose. Based on these models, there are

five factors that may have contributed to the limited impact of the D2B online

community on improvement. I later discuss each of these factors in turn and offer

recommendations for addressing these factors for greater effectiveness in future

OCs.

Online Communities

Online communities are virtual communities that enable connection and

collaboration between individuals on a broad scale through the use of internet

technology.[30] Unlike traditional, non-virtual communities, OCs often consist of

members who do not share geography and who may be unknown to each other in

the real world. Rather, the community-driving element of OCs is often shared

interest.[31] Importantly, the members of the community are also the chief contributors of the very content other members join the community to consume.

Online communities are increasingly important fixtures of the connected world. In the context of rapid proliferation and adoption of internet technology across the globe, the usage of online communities has exploded in recent years as people seek connection with friends and colleagues. For example, usage of one type of online community – social networks – has grown at a torrid pace in the United States. In 2011, 65% of American adults used online social networks as compared with just 8% in 2005.[32]

Today, OCs serve many purposes for many different types of people in a variety of fields. Online communities exist for activities that include everything from socializing (Facebook, Google+, Match.com) to gaming (Xbox Live, World of Warcraft) to creative content development (YouTube, SoundCloud) and content discovery (Last.fm, Yelp, Reddit) to knowledge management (Wikipedia) to entire virtual worlds and marketplaces (Second Life). OCs have also made substantial inroads into the health care industry. In particular, patients and their families have used the internet to seek out other people who share similar health challenges and have formed numerous online communities and support groups, such as PatientsLikeMe.

Online communities are having a greater and greater influence on nearly every industry. But many questions remain about how to design and operate OCs to maximize their positive impact. As such, a new field of study is developing to answer those questions, but it is still in its infancy. I will now examine models for evaluating online community design along the dimensions of community structure and community purpose.

Framework for Evaluating the Structure of Online Communities

Online communities must meet certain basic criteria in order to function properly and effectively. These needs are well described by the media reference model (MRM) developed by Schmid.[33],[34] The MRM stratifies OC needs into four layers or "views" that must be thoughtfully constructed in order to create an effective OC: community, implementation, transaction, and infrastructure (Figure 1).
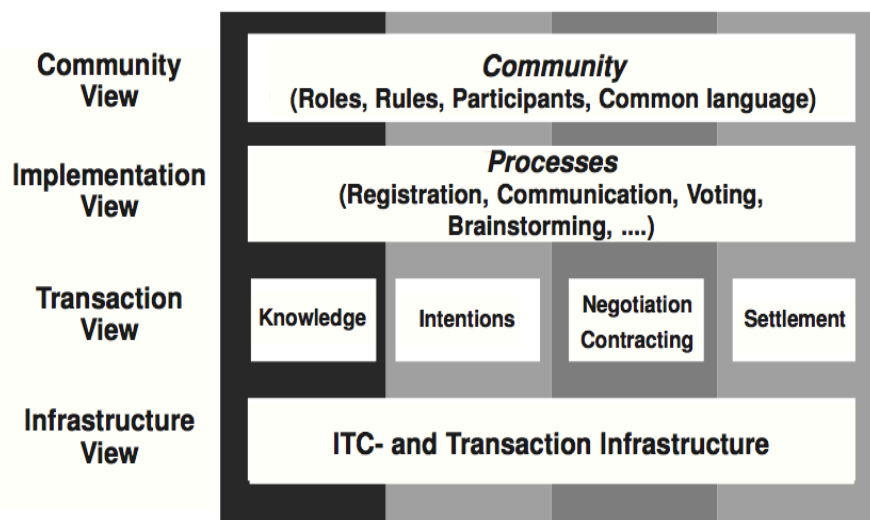

Figure 1: Media Reference Model[34]; (ITC, information technology and communication)

The *community view* outlines the identity and organization of an OC. From this perspective, an OC needs to have well-defined roles, rules, and participants as well as a common language. The *implementation view* describes the fundamental processes of the community, such as registration and discussion participation. How to perform these functions must be clear and publicized to the community members. The *transaction view* portrays how members get what they expect from the OC. This view is broken out into four basic communication and coordination services (knowledge, intention, negotiation, and settlement) that allow OC participants to signal their need for or possession of certain types of knowledge and how that knowledge will be developed and shared. Together, the community, implementation, and transaction views describe how the OC should function. The *infrastructure view*, on the other hand, explains how the underlying technologies and platforms enable an OC so designed. Research suggests that OCs must address each of the components of the MRM in order to build fundamentally sound communities that will support sustained productive interaction between members.[34]

Frameworks for Evaluating the Purpose of Online Communities

Depending on the purpose of the OC, the community, implementation, transaction, and infrastructure layers of an OC will be formed differently. Thus, a wide variety of OC formats has proliferated over the last several decades as the internet has grown and changed. OCs have taken the shape of bulletin board services (BBS), Usenet groups, message boards, online chat rooms, virtual worlds, social networking

services, email listservs, and wikis. Each type of OC is enabled by different technologies that imbue the communities with different characteristics and make them suitable for different purposes. These differences relate to medium (web, email, private network), content (text, audio, visual), participant presence (synchronous vs. asynchronous), and a host of other dimensions. Suffice it to say, there is a complex variety of OC flavors.

Therefore, understanding which types of OCs serve which types of need is a necessary component for strategic and effective OC design. However, neat, widely accepted categorization of online communities has been elusive. Nevertheless, there has been a great deal of research around creating a taxonomy of online communities.[35,36,37] Lazar and Preece[37] provide an overview of the various schema for cataloging OCs, including categorizations by participant attributes, by supporting software, and by relationship to physical communities.

One of the earliest and still most relevant models for OC taxonomy was proposed by Armstrong and Hagel.[38] They advised examining OCs through four different but not mutually exclusive lenses: transaction, fantasy, interest, and relationship. *Communities of transaction* facilitate the exchange of goods and services by bringing supply and demand together as well as allowing users to advise each other on transaction-related topics. Modern day examples would be Craigslist or eBay. *Communities of fantasy* enable members to participate in alternate realities, where they can engage in everything from basic entertainment such as fantasy sports

teams to complete virtual worlds like that offered by Second Life in which users create alter-ego avatars who engage in nearly all the activities of normal human existence. *Communities of interest* unite users who wish to interact extensively with others who share specific interests, such as stock investing at Wikinvest or gardening at Gardenweb. And finally, *Communities of relationship* offer forums for connection with other people who share personal characteristics like illness (PatientsLikeMe) or professional characteristics like being a physician (Sermo). Armstrong and Hagel hypothesized that each type of community meets a specific consumer need, and that consumers are seeking communities where not just one, but many, of those needs are addressed. So, OCs that can provide elements of all four categories are the most fulfilling and valuable to members.

Stanoevska-Slabeva[34] built on Armstrong and Hagel's taxonomy and filtered it through the perspective of community activity and purpose, defining communities by their goals. Broadly, this model categorizes OCs as *discussion communities* (satisfying the need for communication), *task- and goal-oriented communities* (satisfying the need for cooperative achievement of goals), *virtual worlds* (satisfying the need for fantasy and playing), and *hybrid communities* that incorporate multiple elements of the other three.

Communities of Practice

In addition to the two models just described, a third framework to evaluate OC design through the lens of purpose is the community of practice model. Lave and

Wenger first conceived of the community of practice (CoP) concept in 1991,[39] and

they and others have developed the theory substantially since.[40,41,42] A community

of practice is a group of "people who engage in a process of collective learning in a

shared domain of human endeavor."[43] It is an informal collection of individuals who

share an area of expertise, similar experiences, and a common vocabulary for

communication. As a group, they learn from and advise each other on an ongoing

basis. CoPs can be either traditional or virtual communities. Online CoPs can be

viewed as a subset of Armstrong and Hagel's communities of interest, which are

themselves a subset of Stanoevska-Slabeva's discussion communities.

Communities of practice are distinguished from the broader category of

communities of interest in that they are composed of practitioners and experts in a

particular field, not people who merely possess an interest in the topic. CoP

members both contribute to the community based on their real-world experience

and take what they learn from the community and apply it to their practice. Another

distinguishing characteristic of CoPs is that they are not goal-oriented in the same

way that teams are. (See Table 2 below for a comparison of CoPs with other groups.)

Whereas teams are formal associations that have an express goal of delivering a

product, CoPs are informal groupings of people who have no obligations to the

community and who are brought together by their desire to learn from each other,

not by their need to accomplish a task. CoPs could be described as something like

professional support groups in that they are places for practitioners to seek outside

advice and guidance on their work as well as to grow as professionals.

Table 2: Comparison of Group Types

	What's the purpose?	Who belongs?	What holds it together?	How long does it last?
Community of practice	To develop members' capabilities to build and exchange knowledge	Members who select them	Passion, commitment, and identification with the group's expertise	As long as there is interest in maintaining the group
Formal work group	To deliver a product or service	Everyone who reports to the group's manager	Job requirements and common goals	Until the next reorganization
Project team	To accomplish a specific task	Employees assigned by senior management	The project's milestones and goals	Until the project has been completed
Informal network	To collect and pass on business information	Friends and business acquaintances	Mutual needs	As long as people have a reason to connect

Table adapted from Wenger, McDermott and Snyder[41]

Examples of real world communities of practice abound. An often-cited example is that of Xerox photocopy machine repair technicians, who regularly and informally gather to discuss problems with solutions not documented in standard company repair manuals.[44] Another is the CoP of brake engineers at the former DaimlerChrysler, who wanted to keep abreast of the tools and techniques that their colleagues in other divisions – small cars, big cars, trucks, minivans, etc. – use to design brakes.[45]

CoPs often cut across departmental and organizational boundaries. As such, CoPs are viewed as central to knowledge management regimes, especially when the knowledge is tacit know-how that is difficult to capture and document formally. [45] Drawing on common experience and context, participants can share knowledge and aid each other in cooperative problem solving. Indeed, research suggests that CoPs can be highly effective and productive organizational tools.[46] Given these characteristics, communities of practice are ideal knowledge transfer mechanisms and are well-suited to the needs of national health care guideline initiatives that

wish to drive implementation through collaboration of domain experts across

multiple organizations.

However, as communities of practice are informal collections of people, they more

often emerge organically rather than develop as a result of express design. That said,

it is possible to build and actively manage an intentional CoP,[47] but the practice is

more akin to cultivating than creating. Wenger, McDermott, and Snyder outline

seven principles for CoP cultivation[41]:

1. Design for evolution
2. Open a dialogue between inside and outside perspectives
3. Invite different levels of participation
4. Develop both public and private community spaces
5. Focus on value
6. Combine familiarity with excitement
7. Create a rhythm for the community

Designing for evolution means to recognize the community's dynamic nature and

resist the managerial urge to control structure, focus, and membership. Opening an

inside-outside dialogue is key to intentional CoP design in that it is the pathway to

liberating the knowledge created and shared by people inside the CoP. People with

an outside perspective, community managers for example, can help CoP members

see what the community can achieve with the knowledge it creates.

Accepting different levels of participation allows for people with different amounts

of time available for participation or with different learning styles to remain

connected to the community and get something out of it. Similarly, it is important to

offer a variety of forums for participation, both public and private. Different types of

learning are accomplished in different venues, but both are necessary. In public

spaces, the tone and agenda of the group is set and members can see who else is

participating and what other members are getting from their participation. Public

forums and events also help make one-on-one connections that allow for private,

deeper problem solving and learning between CoP members.

In order to keep the community vital for the long haul, it is important to focus on the

value the community provides its members. This means regularly encouraging

members to share with other CoP colleagues explicit details about how they have

derived value from community participation. Managers can also harvest stories

from members for sharing with the community at large.

Finally, it is important to make the CoP something that provides a familiar, neutral

environment for collaboration while also introducing exciting new ideas and people

to the group. In order to strike this balance, it is crucial for the CoP to establish a

rhythm. If conversations, events, and collaborations happen formally and informally

on a steady, routine basis, it is more likely that the CoP will survive long-term. As

previously mentioned, unlike project teams that come together around a task, CoPs

are touchstone communities that depend on personal relationships, so a constant

drumbeat of interactions big and small is vital to creating and maintaining those

bonds. Still, the CoP must excite its members with outside the ordinary activity by

introducing new and interesting thought to experts who thrive on intellectual

growth. This may take the form of bringing in outsiders with unique perspectives or

encouraging insiders to share their cutting edge work. A substantial amount of qualitative research[41,44,46] suggests that these seven principles are associated with developing effective, long-lasting communities of practice. If health care initiatives are able to adhere to these design principles, they may be able to create OCs that support and drive effective knowledge transfer.

Five Factors that Undermined D2B OC Effectiveness

As outlined above, online communities are becoming a larger and larger influence in many industries. As a result, OCs have great potential for driving social change. But harnessing this promise has proven difficult, especially in health care. Despite the perceived helpfulness of the D2B online community, it did not, as described above, have a meaningful impact on door-to-balloon times. This lack of impact may be attributable to the study itself, which may have been underpowered to detect the actual significant relationship between OC use and door-to-balloon times. Additionally, the study may have revealed a currently unappreciated impact of the OC if it had examined different endpoints.

However, assuming the study correctly demonstrated that the D2B online community did not have a statistically significant impact, we can say that the OC failed to achieve the basic goal of evidence-based medicine to alter practice and improve outcomes. Understanding why the D2B online community was unable to accelerate change may help craft strategy for OCs in future health care initiatives. In

this section, I will highlight five factors that I believe limited the D2B OC's effectiveness.

Contributing Factor #1: Poor Structural Design

With respect to online community building in general, the D2B OC inadequately addressed the elements of the media resource model discussed earlier. From the MRM's community view, there were no clear roles, rules, or responsibilities for participants. Rather, hospital key contacts were initially involuntarily assigned to participate in the community with limited instruction on what they were supposed to do in it. It was not clear who was to contribute, what they were to contribute, or how they were to contribute it. It was not even apparent if there were any hierarchy at all, much less where specific community members fit into it. One key improvement may have been to create a small pool of moderators – some from the D2B staff and others from participant hospitals. I believe it would have made a substantial difference if there were moderators gently guiding the conversation in more fruitful directions, encouraging specific types of community output, and filtering out less topical or lower quality contributions. This may have increased the true value of community discussion.

From the MRM implementation and transaction views, the D2B OC again failed to deliver. With regular complaints about the volume and topicality of the messages as well as numerous requests to be unsubscribed from the listserv, it seems clear that there was some yearning among participants for a higher level of order in the

community. Yet, there was no formal description or enforcement of proper etiquette, such as what types of topics were acceptable for conversation or even when to reply to individuals instead of the whole listserv. Nor was it obvious how basic functions of the community worked. As a result, community members were less able to understand what they could expect to get from the community and how to get it. It may have been helpful for D2B staff, in their capacity as moderators, to orchestrate demonstrations of how the community could be used, thereby creating at least one prototype for future interaction.

From the MRM technology view, the D2B OC was also wanting. The listserv had significant technical limitations. First, the online community was split into two apparently separate elements – the listserv and the web portal. Though they were united in some ways, namely the archiving of listserv messages on the portal, the separation provided a less than seamless experience for users, which may have prevented them from taking advantage of the community's full potential. This was born out in the seemingly sparse use of the web portal's functionality. Other technical limitations included the listserv's cap on the size of files that could be transmitted. In practice this cap prevented some participants from sharing useful tools with each other because the files were too large. At best community members circumvented the cap by directly sharing these tools with colleagues at other institutions, but this solution, while perhaps helpful to the two parties involved, did not add value to the online community as a whole.

Another major technical limitation was the email archive. First, it was not easily

accessible. It required creation of an online account with a separate organization,

IHI, and logging into a different interface, the web portal. Second, the archive was

often not a faithful record. In the automatic listserv-to-portal archiving process,

messages with advanced formatting were often corrupted and rendered unreadable

on the portal even if they had been successfully transmitted through the listserv.[*]

This made it impossible for users to review the full transcript of previous

conversations, thereby limiting the usefulness of the archive and precluding users

from learning from discussions that occurred before they joined the community.

This may explain why some conversations threads were repeated multiple times,

much to the frustration of those users who had already read through and

participated in community discussion on the topics. But even if there had been an

easily accessible, uncorrupted, complete archive of listserv discussion, I believe it

would not have served the online community well. The discussion transcript runs

thousands of pages and covers hundreds of topics in no apparent order. It is very

cumbersome to read and understand such a large, disorganized body of knowledge.

This would have made it difficult for a newcomer to the community to become

acquainted with the OC's pre-existing knowledge base and would perhaps prevent

him or her from making new contributions or at least from feeling comfortable to do

so. The sheer volume of messages would have made it difficult even for community

members who had been following along since the beginning to keep up with

everything going on in the community. But an even graver problem was that there

---

[*] Note: the archive accessed through the administrator facility and used for analysis in this and other studies did not suffer from this problem.

was no place a community member, new or old, could turn to learn about the community's current consensus thinking on a particular topic, both because there was no such document and because there was not even a clear consensus to report.

Contributing Factor #2: Incomplete Implementation of CoP Design Principles

The D2B online community was an informal, multi-organizational group of professionals tackling similar problems who met online to share their experience in order to help colleagues improve performance. Therefore, it can be recognized as a community of practice. Research suggests that highly functioning communities of practice can be extremely productive and effective.[46] Therefore, I propose that the D2B community's failure to drive significant improvement is partially attributable to the fact that it did not follow some basic principles of good CoP design. A critical appraisal of the D2B OC as a CoP therefore yields further insight into why online community users did not have significantly better door-to-balloon times than their non-user counterparts. As outlined earlier, there are seven principles for effective CoP design. In the following paragraphs, I will describe how the D2B OC fell short in executing on three of these principles: 1) developing both public and private community spaces, 2) focusing on value, and 3) creating a rhythm for the community.

The success of a community of practice depends on vibrancy in both the public and private spheres. A trap that CoPs can fall into is putting a lot of effort into nurturing the community's public realm through community-wide events – such as listserv

discussions in the case of the D2B OC – and neglecting the private one-on-one interactions that happen away from the entire community's view.[41] Communities frequently fall into this trap because events and discussions that involve the whole community are tangible and visible and seem to benefit every member. On the other hand, private interactions between community members – e.g. direct, non-listserv-mediated communication and collaboration between D2B OC users – are extremely beneficial to the parties involved but not necessarily to the larger community. It is possible that a lot of problem solving around the challenges of guideline implementation occurred in the D2B OC when one hospital's staff contacted their counterparts at another hospital to initiate direct (perhaps even offline) contact and work together towards solutions to shared problems. This is exactly the kind of collaborative interaction that an OC is uniquely equipped to facilitate. However, such interaction only benefits those directly involved in it.

A solution to this problem, and one that the D2B OC could have employed to greater effect than it did, would have been to get community coordinators out "into the field" to harvest information from these back channel, private interactions. Equipped with broad knowledge about what was happening out of public view, community coordinators could have brought the successes, challenges, and other issues participant hospitals were encountering to the attention of the CoP at large. This would have delivered valuable insights to a larger population of OC users while also driving richer conversation in the public sphere. Additionally, the coordinators could act as matchmakers and create new private relationships between participant

hospitals or point them to other useful resources inside or outside the community, thereby accelerating progress toward successful guideline implementation and possibly creating more valuable knowledge for public consumption.

The need for community coordinators to publicize the value of private interactions is a component of a larger imperative for successful CoP building – the need to focus on value. Just as private interaction is often hidden in CoPs, so too is the value of the community. For a CoP to remain vital over the long haul, it needs to remain helpful to its members. But that value is difficult to measure because it comes in the form of a series of interactions big and small, public and private whose effects may not be realized immediately. Therefore a key component of CoP success is to help community members become aware of the value that the community can provide them. This is done by encouraging community members to be explicit about what they have gained from their participation in the group.

In the D2B OC, for example, it would have been constructive to have hospitals share stories and even quantitative metrics of the impact of various insights they gleaned from the OC. Success breeds success in CoPs,[41] so if D2B campaign participants were to see that others were learning valuable lessons from OC participation and achieving implementation goals as a result, they might engage the OC more seriously, seek out the story sharers as role models, and perhaps even become mentors themselves. Unfortunately, this was not a common occurrence in the D2B

OC. In fact, only 6% of all listserv messages focused on expressions of community value, as shown in **Table 1** above.

A final CoP design weakness in the D2B OC was the sporadic nature of activity. As discussed earlier, productive CoPs have a rhythm to their activities so that participation becomes a routine part of members' professional lives. Therefore, it is necessary to have regular – and therefore anticipated – events. For example, in the D2B OC, there could have been a monthly highlight of a hospital that had succeeded in implementing one of the recommended D2B practices or a weekly expert Q&A session on common challenges faced by hospitals. A regular drumbeat of activity gives CoP members an idea of what to expect from the community and to make space for it on their busy agendas. Doing so would further ensure longevity for the CoP by creating activity that has the potential to sustain user engagement beyond the early euphoria that often accompanies the launch of a new community. In the absence of this drumbeat of activity, D2B OC engagement diminished rapidly over time. This may explain part of the OC's lack of impact.

Contributing Factor #3: Choice of Listerv as the Primary OC Medium

The failings of the D2B OC as an OC in general, and as a CoP more specifically, may have been partially driven by the central role the listserv played in the community. Listservs are not very conducive to the type of knowledge sharing that is needed to aid EBM guideline implementation. Traditionally, knowledge has been classified as one of two types: tacit or explicit.[48,49] Tacit knowledge is contained in a person's

head and can be likened to "know-how." Speaking a language or playing a sport are examples. Explicit knowledge, on the other hand, is factual, and can be thought of as "know-what." The key difference between tacit and explicit knowledge is that the latter is more easily expressed and therefore more easily transferred. Applying this to the health care realm, it would be far easier to teach a group of professionals the fact that studies show door-to-balloon times under 90 minutes reduce morbidity and mortality than it would be to teach that same group how to run a system that achieved sub-90-minute door-to-balloon times.

The type of knowledge exchanged in the D2B OC may explain why use of the D2B online community did not have an impact on outcomes. Because the D2B OC was largely email based, it was easiest to share explicit knowledge that was more readily expressed in text or tools, such as measurement spreadsheets, presentations to educate hospital staff, or links to the evidence behind recommended practices. Thus, the listserv was a forum for trading explicit knowledge tools and less for sharing of tacit knowledge needed to implement recommended guidelines effectively.

As tacit know-how is difficult to capture and express, it is reasonable to assume that a group of people collaborating will be better able to build and share the necessary tacit knowledge than any individual. Therefore, I suggest then that a listserv may have been a poor choice of online community format. Listservs lend themselves to quick, multi-party discussion. Each member makes discrete contributions completely of his or her own creation. This is antithetical to collaboration. The final

product of a collaborative community should be a consensus that is the seamless result of many contributors' input. This is not possible with a listserv as there is no common product upon which many people can work. Additionally, there is no control on the quality of each contribution nor any mechanism to filter out bad content. And since listservs give equal attention to all contributions by sending all messages to the whole group with equal priority, there is serious potential for degrading the overall quality and value of the community. Perhaps a collaborative online community platform, such as a wiki, that was aimed at developing a series of "how-to" documents would have better served the D2B initiative's needs for expressing and sharing tacit knowledge.

Contributing Factor #4: Unmet OC Member Needs

As discussed earlier, Armstrong and Hagel defined several categories of online community member needs and suggested that members would be more satisfied by OCs that met more of them. Given the many design shortcomings of the D2B OC, it is reasonable to assume that some OC member needs were unmet, which could have led to lower levels of engagement and thus partially explain the OC's limited effectiveness.

Of the several needs described in Armstrong and Hagel's model perhaps the most relevant to a health care initiative OC are transaction, interest, and relationship. The D2B OC did, in fact, address all three by providing a forum for professionals with

similar interests to meet, develop new relationships, and trade knowledge, but it did not completely satisfy those needs.

The chief good transacted in the D2B OC was knowledge. OC members presumably sought high quality advice in high quantities. As described above, the D2B OC was lacking in both dimensions. There were limited quality controls on contributions to the OC and the OC's activity rapidly and substantially dropped off after launch. With respect to building a community of shared interests and to creating new relationships, by bringing together a nationwide group of professionals focusing on the same, highly specialized issues, the D2B OC did actually provide a forum that offered a service previously unavailable to OC members. However, the D2B OC could have been more tailored by providing additional interest subgroups for physicians, nurses, and administrators, allowing each group to delve more deeply into the D2B topics very specific to their roles. Doing so may have made the D2B OC more appealing and therefore drawn in more members. This would have been especially helpful in attracting physicians, who already have many potential outlets for finding colleagues with shared interests, such as conferences and professional societies. Additionally, relationship building itself was inefficient in the D2B OC. There was no mechanism to search for potential colleagues based on specific characteristics. For example, it was not possible for an OC member to scan a list of physicians working in 100-200 bed community hospitals in his or her state to find a new collaborator. Rather, OC members had to hope such a person would send a message to the listerv. Of the hundreds of people subscribed to the OC, only 206 sent a message to the

listserv. Therefore, the number of relationships developed may have been lower than it could have potentially been.

Contributing Factor #5: Community Members and Their Skill

No matter how valuable and vibrant an online community may be, ultimately, the true ability to effect change in an organization lies with the people who have to take what they learn from the community in cyberspace and implement it in reality. Therefore, I argue that *who* is in an online community will determine the OC's success as much as the quality of the community will.

In the D2B OC, nurses dominated the group, comprising 70% of all users, while physicians were only 8%. This breakdown is not uncommon in quality improvement activities, but given the physician-driven nature of most of the D2B Alliance's recommended strategies for door-to-balloon time reduction, it is perhaps not surprising that the nurse-heavy OC user base had difficulty effecting change.[26,50]

Similarly, fewer than half the hospitals participating in the online community (n=164 of 378) had more than one staff member signed up for the OC. For the hospitals with a lone OC participant, it is easy to imagine that bringing insights and enthusiasm from the OC back home would be difficult without shared context and without support from other OC-member colleagues, making it that much harder to implement in the real world what was learned in the virtual community.

Finally, we must also consider the computer literacy of OC participants, as the lack of technical abilities among the users could have hindered realization of the OC's potential. While there is no explicit data from the present study to render judgment, we do have some clues that internet and computer skills may have been subpar, including the relatively regular need for users to discuss OC technical issues via listserv messages and the almost complete lack of use of the web portal. Additionally, it is likely that most OC members were mid-career professionals in 2007-2008. Therefore, they did not grow up steeped in computer and internet culture, meaning they may have less facility and comfort with the online environment. It would be of probative value for future studies to assess the computer literacy of OC users.

Conclusion

The goal of this paper was to explore whether or not online communities could accelerate the adoption of evidence based guidelines. Examination of the D2B Alliance's OC showed that OC participation was not associated with performance improvement. However, a review of online community theory suggested that OCs do have the potential to drive change. It is conceivable that D2B OC users had the desire to collaborate and possessed valuable knowledge to share but that the structure and dynamics of the community hindered their ability to do so, thus muting the potential of the OC.

Despite the OCs limitations, the participants in the D2B OC were still able to communicate to a great extent, and they felt that engagement with the community was helpful, even if it did not impact clinical outcomes. But with changes to its design and some additional curation and attention by moderators and community coordinators, the D2B OC might have been a more engaging and helpful resource to hospitals participating in the D2B Alliance. However, it should be noted that some of these changes most likely would have demanded more time and resources from both D2B initiative staff and OC members themselves. It is unclear whether making the suggested improvements to the OC would have been the most valuable way to invest those resources. Research to address that question would help guide the design of future health care initiative OCs.

In conclusion, the present study does not allow for a final answer to the question of whether online communities can accelerate guideline adoption because the D2B OC itself was not properly designed. It is important, therefore, for future research to readdress this question with a health care initiative OC that is closer to ideal design.

Appendix A: Methods for Studying the D2B Online Community[†]

Study Design

In our published paper, we report the results of our longitudinal study of the D2B

Alliance OC. In that paper, we sought to describe 1) who joined the D2B online

community, 2) how they used it, and 3) if community participation had an impact on

the hospitals that used it.

Sample and Data Sources

We identified D2B online community users through two data sources. Our first

source was the D2B Alliance Follow-up Survey data, described elsewhere,[51]

collected from 715 of 797 (90% response rate) that indicated they would

participate in a study of D2B hospitals. Hospitals were surveyed online about a year

after their enrollment in the D2B Alliance (median time=12 months). Our second

source of data was the archive of email messages sent to the online community from

March 29, 2007, the launch date of the community, through February 29, 2008, the

last day the D2B Alliance officially supported the community.

We identified hospitals as users of the D2B online community by two mechanisms:

1) if a hospital responded affirmatively to the survey question, "Did staff at your

hospital participate in the D2B Alliance Online Community?" and/or 2) if through

---

[†] A complete description of methods and results can be found in Nembhard IM, Nazem AG, Webster TR, Wang Y, Krumholz HM, et al. Understanding the use and impact of an online community in a national quality improvement campaign. *BMJ Qual Saf.* 2011 Jan;20(1):68-75.

examination of the email archive, a hospital's staff was found to have contributed messages to the online community. Hospitals that indicated that their staff had not used the online community in the survey were designated as non-users. The total sample size of users and non-users was 731, representing the 715 survey respondents as well as 16 additional hospitals that had not completed the survey but whose staff had contributed messages to the community. Hospitals determined to be users of the online community by the above methods were further categorized as either contributing or silent users, depending on whether or not the email archive contained messages to the community from that particular hospital's staff. To examine the characteristics of user hospitals versus non-user hospitals, we obtained data from the American Hospital Association Hospital Survey for 2005,[52] which provided information on number of staffed beds, teaching status, ownership type (non-profit, for-profit, government) and geographic location. From a survey completed by the hospitals at the time of enrollment, we were able to determine how many of the D2B Alliance's five recommended practices the hospitals were engaged in at the outset of the initiative.

To understand how the online community was used, we obtained the full text of each message in the email archive, which was available on the OC's web portal as well as through a separate electronic tool available to administrators of the listserv, which some of my colleagues and I were. This data allowed us to determine the contributing individuals' professions as well as the volume, timing, purpose, and subject of messages sent.

To examine the impact of the online community on the hospitals that joined it, we obtained both subjective and objective data. Our subjective data were hospitals' responses to the question, "Please rate how helpful you found (this) D2B Offering (1=not at all helpful; 5=very helpful)" in the previously mentioned survey, which asked respondents about the helpfulness of a variety of D2B Alliance offerings. For our objective measure of the community's impact, we examined the association between participation in the community and changes in door-to-balloon times, the main clinical outcome of the D2B Alliance, using data from the National Cardiovascular Data Registry (NCDR). Of the 731 hospitals in our sample described above, 486 hospitals had the necessary data available in NCDR.

Data Analysis

Using the data collected about each hospital from the American Hospital Association's survey and the D2B Alliance Follow-up Survey, we ran statistical analyses (chi-square for categorical variables and t-tests for continuous variables) to compare the population of user hospitals vs. non-user hospitals as well as contributing hospitals vs. silent hospitals. These analyses were conducted by other members of the team.

We also conducted a rigorous content analysis of the full text of every message in the email archive. The lead author read all of the messages in the archive sent during the 11-month study period and coded each for multiple attributes, using

standard coding procedures. [53] I also read and coded all messages in the archive

sent during the first 4½ months of the study period. Each of us developed our own

code structure using the constant comparative method of data analysis,[54] iteratively

building a set of codes based on increasingly refined understanding of the online

community, its characteristics, and how to capture its essence consistently. In order

to determine the accuracy and reliability of the coding, the codes as assigned by

each collaborator were compared across 10% (n=116) of all messages in the

archive. The codes exhibited a high level of agreement, with 93% and 95% of the

compared messages being coded for the same purpose and subject, respectively, by

both collaborators. The results presented are based on the lead author's coding of

the complete dataset.

Each message was coded for two sets of attributes. First, it was coded for descriptive

facts about the message and its writer, such as the date the message was sent,

whether the message began a new thread or was in reply to a previous message, and

the writer's profession and home institution. Second, each message was coded for

its content i.e., its purpose (e.g. the writer was seeking or was sharing information)

and its subject (e.g. how to manage staff role changes). Using the coded information,

we were able to describe many attributes of the community. We were able to

compare the professions of message contributors, to characterize the volume and

rate of contributions to the community over time, and to catalog and quantify the

various purposes and subjects of messages.

Finally, we analyzed both subjective and objective data about the impact of the online community using statistical analyses performed by the first author. For subjective measurement, we compared the responses of contributing vs. silent hospitals using chi-squared tests. Using correlation analysis, we further examined if there were a relationship between the volume of messages sent by a hospital and perceived helpfulness. For objective assessment of the OC's impact, linear regression was used to compare the percent changes in door-to-balloon times over the course of the D2B Alliance between OC non-users, contributing users, and silent users.

Appendix B: Understanding the use and impact of an online community in a national quality improvement campaign.

The article reproduced below and referenced throughout this thesis was originally published in *BMJ Quality and Safety* in January 2011.[26]

Understanding the use and impact of the online community in a national quality improvement campaign

Ingrid M Nembhard,[1,2] Alexander G Nazem,[3] Tashonna R Webster,[1,5]
Yongfei Wang,[3,4] Harlan M Krumholz,[3,4] Elizabeth H Bradley[1]

► An additional appendix is published online only. To view this file please visit the journal online (http://qualitysafety.bmj.com).

[1]Yale University, School of Public Health/School of Medicine, New Haven, Connecticut, USA
[2]Yale University, School of Management, New Haven, Connecticut, USA
[3]Yale University, School of Medicine, New Haven, Connecticut, USA
[4]Yale-New Haven Hospital, Center for Outcomes Research and Evaluation, New Haven, Connecticut, USA
[5]Center for Public Health and Health Policy, University of Connecticut, East Hartford, Connecticut, USA

Correspondence to
Ingrid M Nembhard, Yale University, 60 College Street, PO Box 208034, New Haven, CT 06520-8034, USA; ingrid.nembhard@yale.edu

Accepted 20 September 2010

Background: National quality campaigns often sponsor online communities; however, little is known about whether and how organisations use these communities, and the impact of their use.
Methods: We conducted a longitudinal study of the D2B Online Community, which was sponsored by the D2B Alliance, a campaign to improve heart attack care. We examined community use, helpfulness, and impact on care for 731 Alliance-hospitals. Our data sources were a hospital survey, the archive of messages sent and the National Cardiovascular Data Registry's time-to-treatment data.
Results: About 52% of hospitals (n=378/731) studied used the online community, with 27% of hospitals (n=195) contributing messages to the online community, while 25% (n=183) were silent users. Silent users were hospitals that reported staff use of the online community, but their staff did not send any messages. In the vast majority of contributing hospitals, only one individual contributed messages to the community. Contributing individuals, mostly nurses (70%), sent a total of 1155 messages, with 36% of messages sent by 11 high-volume users (5%). Messages discussed techniques for improving performance, performance measurement issues, location and interpretation of expert guidance and how to manage staff role changes. We found no statistical association between community use and improved time-to-treatment; however, many users rated the community highly for helpfulness.
Conclusion: Many organisations used the online community for information exchange and found it helpful, despite its lack of association with performance improvement, suggesting what benefits there are may not directly link to performance.

Healthcare organizations have joined national quality campaigns in several countries.[1][2] Campaigns have included the 5 Million Lives Campaign[3] and D2B: An Alliance for Quality[4] primarily in the United States, the Patient Safety First Campaign in the United Kingdom and Operation Life in Denmark.[5] These campaigns offer opportunities for organisa-tions to learn about evidence-based practices and their implementation. Online communities are a common campaign offering; however, little is known about whether organisations and their staff use them and the contribution of these communities to quality improvement. Previous studies of online communities in non-healthcare settings indicate that only 10% of members send messages.[6][7] We found no studies of their use in multi-organisational quality improvement efforts in healthcare. However, the popularity of quality campaigns and their sponsorship of online communities suggest the importance of understanding the role of these communi-ties in improvement efforts.

Therefore, we examined the use of the D2B Online Community,[8] which was launched as part of the D2B Alliance national campaign to improve quality of care for patients with ST-segment elevation myocar-dial infarction (STEMI). Specifically, we assessed whether organisations and their staff joined the community, characteristics of those that joined, how often they used it, how they used it, their views on its helpfulness, and the relationship between their use and improved treatment times for patients with STEMI. Our findings offer insights on the use and impact of online communities and how to enhance their effectiveness.

METHODS

Setting
The D2B Alliance enrolled more than 1000 U.S. hospitals.[4] It offered them access to an information packet ('change package') on strategies to improve care for patients with STEMI, an implementation toolkit, webinars, and a mentor network of successful organisa-tions willing to advise peers. In addition, the

designated contacts for hospitals received an email invitation to join the online community with instructions on how to extend the invitation to other staff in their hospital. Individuals accepted the invitation by registering online with the community. During registration, individuals were informed that the community listserv would be operated by the Institute for Healthcare Improvement and discussions would be driven by community members.

Study design, sample and data

We conducted a longitudinal study of the D2B Online Community, including its users and their messages, using surveys and content analysis of archived email messages. We identified D2B Online Community users through two data sources. Our first source was the D2B Alliance Follow-up Survey data, described elsewhere,[9] collected from 715 of the 797 hospitals participating in an evaluative study of hospitals that enrolled in the D2B Alliance during its first 6 months (November 2006–June 2007; 92% response rate). Hospitals were surveyed online about a year after their enrollment in the D2B Alliance (median time=12 months; range: 9.3–17.1 months). We identified D2B Online Community users by their affirmative response to the survey question, 'Did staff at your hospital participate in the D2B Alliance Online Community?' Our second source of data was the archive of email messages sent to the online community from 28 March 2007, the launch date for the community, through 29 February 2008, the last day of support from the campaign.

Using these two data sources, we designated contributing and silent hospital users. Hospitals with staff that sent messages were designated contributing hospitals. Similarly, their message-sending staff was termed contributing individuals. We included 16 hospitals that had staff that sent messages to the community but had not completed the survey because we sought to provide a complete description of the contributing hospitals and individuals, and their messages. Their inclusion increased our sample size from 715 to 731 hospitals. Hospitals that reported on the survey that they used the online community but that they had no staff send messages to the community were designated silent hospitals. Presumably, the silent hospitals had staff that read the messages exchanged by contributing hospitals' staff. All other D2B Alliance hospitals—not designated as contributing or silent users of the online community— were designated non-user hospitals.

To examine characteristics of user hospitals (contributing and silent) versus non-user hospitals, we obtained data from the American Hospital Association Hospital Survey for 2005,[10] which provided information on number of staffed beds, teaching status (with teaching hospital defined as one with a residency program accredited by the American College of Graduate Medical Education), ownership type (nonprofit, for-profit, government) and regional location (four Census regions). We also obtained information on the number of D2B Alliance-recommended practices reported to be in use at the time of enrollment in the campaign from the survey[9] completed by hospitals upon enrollment. We reviewed the full-text of the message archive to determine contributing individuals' professions as well as the volume, purpose, subject and timing of messages sent. To examine the impact of the online community, we then examined the helpfulness of the online community by assessing survey responses to the question: 'Please rate how helpful you found (this) D2B Offering (1=not at all helpful; 5=very helpful).' For a more objective assessment of impact, we also examined the association between community use and change in treatment (door-to-balloon) times for patients with STEMI using data from the National Cardiovascular Data Registry for hospitals in the registry (N=486).

Data analysis

We used descriptive statistics to characterise the hospitals whose staff used the D2B Online Community. We compared the characteristics of user and non-user hospitals using chi-square for categorical variables and t-tests for continuous variables. We used the same tests to compare the characteristics of contributing and silent hospitals.

To determine contributing individuals' professions and the volume, purpose, subject and timing of their messages, we conducted a content analysis of the archived messages from the D2B Online Community using the standard approach of coding messages for their core characteristics.[11] We coded each message for two sets of attributes. The first set of attributes characterised the contributing individual: profession and home institution. In the instances when messages did not include the contributing individual's profession or institution, we obtained this information through an internet search or from the American College of Cardiology in response to our request. Contributing individual's profession was coded as physician, nurse, allied health professional, non-clinical hospital staff or D2B Alliance faculty. The second set of attributes characterised the messages sent: the date sent, whether the message started a new conversation or was a reply message, the purpose of the message and the subject of the message. The purpose of the message was the inferred intent of the contributing individual in sending the message, while the subject of the message was the topic discussed in the communication. We used the constant comparative method of data analysis[12] to arrive at separate taxonomies for purpose and subject of

message. This method involved comparing messages with a list of codes that were iteratively developed to reflect the purpose and subject of messages and then cataloguing messages using the appropriate codes. We conducted this analysis using ATLAS.ti.[13] To assess the reliability of the coding, two investigators (IMN and AGN) independently coded the purpose and subject of the first 10% of messages (n=116). Agreement between their coding was high with 93% and 95% of messages being coded the same for purpose and subject, respectively; therefore, one investigator (IMN) coded the remaining messages. We used descriptive statistics to report the findings from our content analysis of messages, including contributing individuals' professions, number of new messages, and the timing, purpose and subject of messages.

We also used descriptive statistics to examine users' ratings of the online community's helpfulness, our first measure of the community's impact. We then compared helpfulness ratings between the two user subgroups—contributing and silent hospitals—using a χ^2-test, and conducted correlation analysis to assess the relationship between ratings and number of messages sent. Both of these analyses examine whether greater use of the community is associated with higher helpfulness ratings. For a more objective evaluation of community impact, we used linear regression to assess the relationship between community user status (contributing, silent or non-user) and percentage change in mean door-to-balloon time between the 2 years prior to the start of the online community (April 2005–March 2007) and the last quarter of D2B Alliance programming (January–March 2008). We adjusted for the five hospital characteristics mentioned above and the number of other campaign offerings used (of 11 offerings possible). The institutional review board at our university approved these methods, having decided that our study posed little risk to community members.

RESULTS

Who used the online community?

A total of 378 of the 731 hospitals in our sample (52%) were identified as users of the D2B Online Community. Users were significantly (p<0.01) more likely than non-users to be non-profit and to be located in the Midwest (table 1), although online community users were distributed across the USA, with many located in the same service market (ie, county or proximate counties) as other users (figure 1). There were no significant differences between user and non-user hospitals in baseline number of D2B Alliance-recommended practices implemented, teaching status or number of staffed beds (p-values>0.05).

Table 1 Characteristics of D2B Online Community Hospital users (N=378) and non-users (N=353)

Characteristic	Users* N (%)	Non-users N (%)	p-Value†
Recommended practices at baseline			0.79
0	35 (9)	36 (10)	
1	82 (22)	77 (22)	
2	171 (45)	148 (42)	
3	74 (20)	82 (23)	
4	7 (2)	8 (2)	
Unknown	9 (2)	2 (1)	
Mean	1.8	1.9	0.69
Teaching status			0.54
Non-teaching	191 (51)	189 (54)	
Teaching	174 (46)	157 (44)	
Unknown	13 (3)	7 (2)	
Number of staffed beds			0.36
<300 beds	164 (43)	153 (43)	
300–600 beds	161 (43)	143 (41)	
>600 beds	40 (11)	50 (14)	
Unknown	13 (3)	7 (2)	
Ownership type			<0.001
Government	31 (8)	35 (10)	
Non-profit	301 (80)	230 (65)	
For-profit	33 (9)	81 (23)	
Unknown	13 (3)	7 (2)	
Regional location			0.01
Northeast	62 (16)	49 (13)	
Midwest	125 (33)	81 (23)	
South	126 (33)	155 (44)	
West	63 (17)	66 (19)	
Unknown	2 (1)	2 (1)	

*Users consisted of 299 hospitals that reported in the hospital survey that their staff used the D2B Online Community as well as 79 additional hospitals that did not report in the survey that their staff used the D2B Online Community but whose staff nonetheless were found to have sent at least 1 message. Of these 79 hospitals, 38 hospitals had reported on the survey that their staff did not use the online community, 23 hospitals had reported on the survey that they did not know if their staff used the online community, and 18 hospitals had left the survey item blank or had not completed the survey.
†p-Values based on χ^2 for categorical variables and t-test for continuous variables.

Who contributed messages?
Contributing hospitals

A total of 27% of hospitals had staff who contributed messages to the online community, and 25% had staff who were silent users, that is, the hospital reported that staff used the online community but no messages from its staff were found, suggesting these users may have been reading but not contributing messages. We found no significant differences between hospitals with contributing staff and hospitals with silent staff in terms of baseline number of D2B Alliance-recommended practices implemented, teaching status, staffed beds, ownership type or regional location (p-values>0.05). In 96% of the contributing hospitals, only one individual contributed messages to the community. In the other

Figure 1 Location of D2B Online Community Hospital users (indicated by pins).
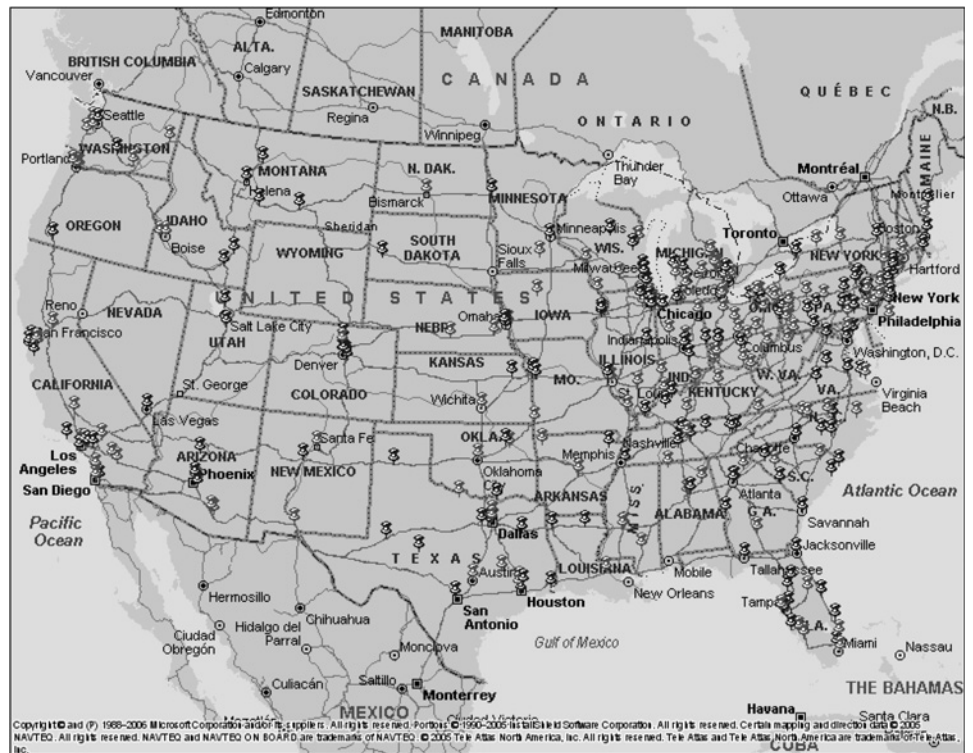
4%, two individuals per hospital contributed messages; thus, the total number of contributing individuals was 206, including 5 D2B Alliance faculty.

Contributing individuals' professions
Almost 9% of contributing individuals were physicians and 70% were nurses by training. The remaining individuals were allied health professionals (3%), non-clinical hospital staff (3%), D2B Alliance faculty (2%) or of unknown profession (12%). Most contributing individuals worked in departments of cardiovascular services (60%) or quality/performance improvement (31%); 54% held managerial positions.

How contributing individuals used the community
How much individuals used the community
A total of 1155 messages were sent to the online community during the study period, for an average of 5.6 (N=1155/206) messages per individual. However, as figure 2 shows, this average is skewed by the large contributions of a small group. About 36% of the messages came from 11 (5%) individuals who sent 20 or more messages, that is, high-volume individuals, including a project coordinator who sent 93 messages. Without high-volume users, the average number of messages per individual was 3.8; however, 35% of contributing individuals sent just one message. We found no significant difference between high-, moderate- and low-volume users in terms of number of recommended strategies used at baseline at their hospital or any other hospital characteristic that we studied (p-values>0.05), except for

geographic location. Midwestern users were disproportionately moderate-volume users (p-value<0.05).

Starting a new topic and community responsiveness
Only 13% (n=154) of messages started a new topic of conversation. In most cases (82%), these messages received a response, generating a total of 1001 reply messages, with an average of 6.5 replies for every new-topic message sent. At the maximum, 1 new-topic message generated 40 replies.

Purpose and subject of messages
Our content analysis revealed seven purposes for messages sent to the community as listed in table 2. Among messages that started a new topic of conversation, the majority were information-seeking (121/154=79%). As table 3 shows, contributing individuals discussed subjects related and unrelated to D2B Alliance goals. (An online appendix provides a sample of messages that illustrate the subjects.)

When contributing individuals used the community: the timing of messages
The daily average number of messages sent to the community was 3.3 messages. One-third (n=389) were sent in the first 2 months of the community (figure 3) when the average number of messages per day was 6.4 (S.D=10.5). During the next 2 month period, which began with the campaign's introduction of webinars, the average number of messages per day dropped 43% to 3.7 messages (SD=5.3). In the subsequent 3 months, which

50
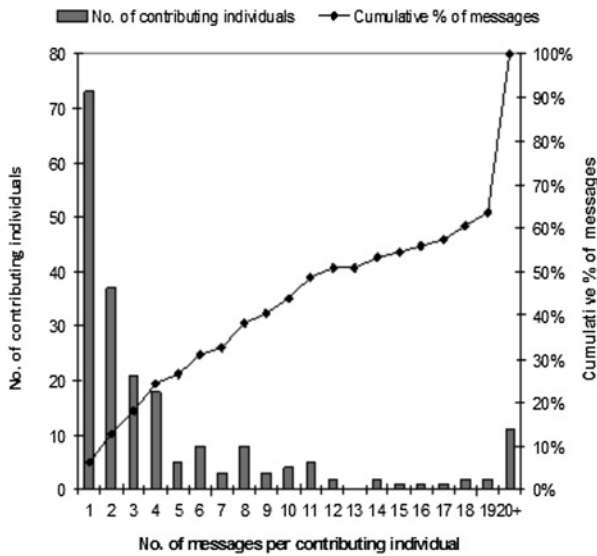
Distribution of contributing individuals by profession and volume of messages and profession			
	No. (%) of contributing individuals		
	Low-volume users: ≤10 messages sent	Moderate-volume users: 10>messages sent>20	High-volume users: ≥20 messages sent
Physicians (N=17)	13 (76)	1 (6)	3 (18)
Managers	6 (35)	0 (0)	2 (12)
Staff	7 (41)	1 (6)	1 (6)
Nurses (N=145)	125 (86)	13 (9)	7 (5)
Managers	74 (51)	2 (1)	1 (1)
Staff	51 (35)	11 (8)	6 (4)
Allied professionals (N=7)	6 (86)	0 (0)	1 (14)
Managers	5 (71)	0 (0)	1 (14)
Staff	1 (14)	0 (0)	0 (0)
Non-clinical staff (N=7)	6 (86)	1 (14)	0 (0)
Managers	5 (71)	0 (0)	0 (0)
Staff	1 (14)	1(14)	0 (0)
Unknown profession (N=25)	24 (96)	1 (4)	0 (0)
Managers	10 (40)	0 (0)	0 (0)
Staff	5 (20)	1 (.04)	0 (0)
Unknown	9 (36)	0 (0)	0 (0)
D2B faculty (N=5)	5 (100)	0 (0)	0 (0)
Total by volume (N=206)	179 (87)	16 (8)	11 (5)
Messages sent (Total =1155)	509 (44)	226 (20)	420 (36)

Figure 2 Distribution of messages per contributing individual.

began with the campaign's mailing of tailored reports that indicated which recommended practices each hospital had not implemented based on the baseline survey, the daily average number of messages (3.4; SD=5.3) remained virtually the same as in the prior 2 months. In the final 4 months, which began with campaign-sponsored workshops at the AHA meeting, the daily average number of messages decreased substantially again (48%) to 1.8 messages (SD=3.7).

Community use, perceived helpfulness and change in door-to-balloon times

Nearly 62% of self-reported hospital users (contributing and silent) of the D2B Online Community rated the helpfulness of the online community as 4 or 5 on a scale ranging from 1=not at all helpful to 5=very helpful. The distribution of helpfulness ratings did not differ significantly between hospitals whose staff contributed messages and those whose staff were silent (59% and 63% giving

Table 2 Taxonomy of purposes of D2B Online Community messages (N=1155)

Purpose of message	No. (%) of messages*	Sample message
Information-sharing	657 (57)	This is the spreadsheet we use here at Hospital X for Cardiac Alert. This spreadsheet has been very helpful in decreasing door to balloon time—Nurse
Information-seeking	295 (26)	Do any hospitals have the ER physicians and nurses obtain consent for their STEMI patients in the ER to save time?—Nurse, Quality Improvement
Declaring a position on an issue	137 (12)	I agree. It is important that we are measuring our outcomes the same in order to benchmark correctly. − Nurse, Manager, Cardiovascular Services
Expressing appreciation for information or community	72 (6)	Thank you for sharing (your feedback tool). That is a great way to give the feedback. Adding the ECG is something I will do now. Nice format. Thanks again—Nurse, Quality Improvement
Handling listserv errors, system- or user-induced	51 (4)	Is it possible to increase the size of file transfer capability (on listserv)? I have several tools I would like to share but can never send because the pdf is too large. Thanks.—Nurse, Quality Improvement
Establishing community norms for sharing and replying	37 (3)	Look forward to seeing any other useful tools for provider feedback. Remember that a cornerstone for quality improvement activities is to 'share selflessly and steal shamelessly'—so feel free to use this (attached tool) if you like it—Physician Cardiovascular Services
Planning additional activities, for example new webinars or face-to-face meetings	20 (2)	Hi, I will be in DC for the NCDR quality meeting. If anyone wants to meet that would be great—Nurse, Manager, Cardiovascular Services

*Sum of messages (percentages) is greater than N (100) because 6% of messages had more than one purpose.

Table 3 Taxonomy of subject areas for D2B Online Community messages (N=1155)

Subject of message	Specific concerns	No. (%) of messages*
Related to D2B Alliance-recommended practices and performance goal		
Techniques for improving performance	► Technological options ► Protocol- or tool-based options ► Process-based options	602 (52)
Performance measurement issues	► How to measure performance ► Identifying performance norms ► Using performance benchmarking to identify and learn from best performers	251 (22)
The location and interpretation of expert guidance	► Regulations and guidelines ► Published evidence for recommended practices	98 (8)
How to manage staff role changes	► Informing staff of new roles ► Dealing with staff resistance ► Defining appropriate behaviour	20 (2)
Unrelated to D2B Alliance-recommended practices and performance goal		
Achieving other organizational goals	► Managing other hospital processes ► Measuring other performance outcomes ► How to achieve other benefits, for example, Chest Pain Center Accreditation	151 (13)

*Sum of messages (percentages) is less than N (100) because the subject of messages that involved a listserv error (system or user-induced; 3%) could not be determined.

a rating of 4 or 5 among contributing and silent hospitals, respectively; p-value>0.05). However, hospitals' ratings of helpfulness were positively correlated with the number of messages they sent (p-value<0.05). The association between community user status and percentage change in the mean door-to-balloon time between the 2 years prior to the start of the online community and the last quarter of D2B Alliance programming was positive but not statistically significant (p-value>0.05). Thus, although many users believed the community was helpful, their perception was not reflected in significantly improved treatment times relative to non-users.
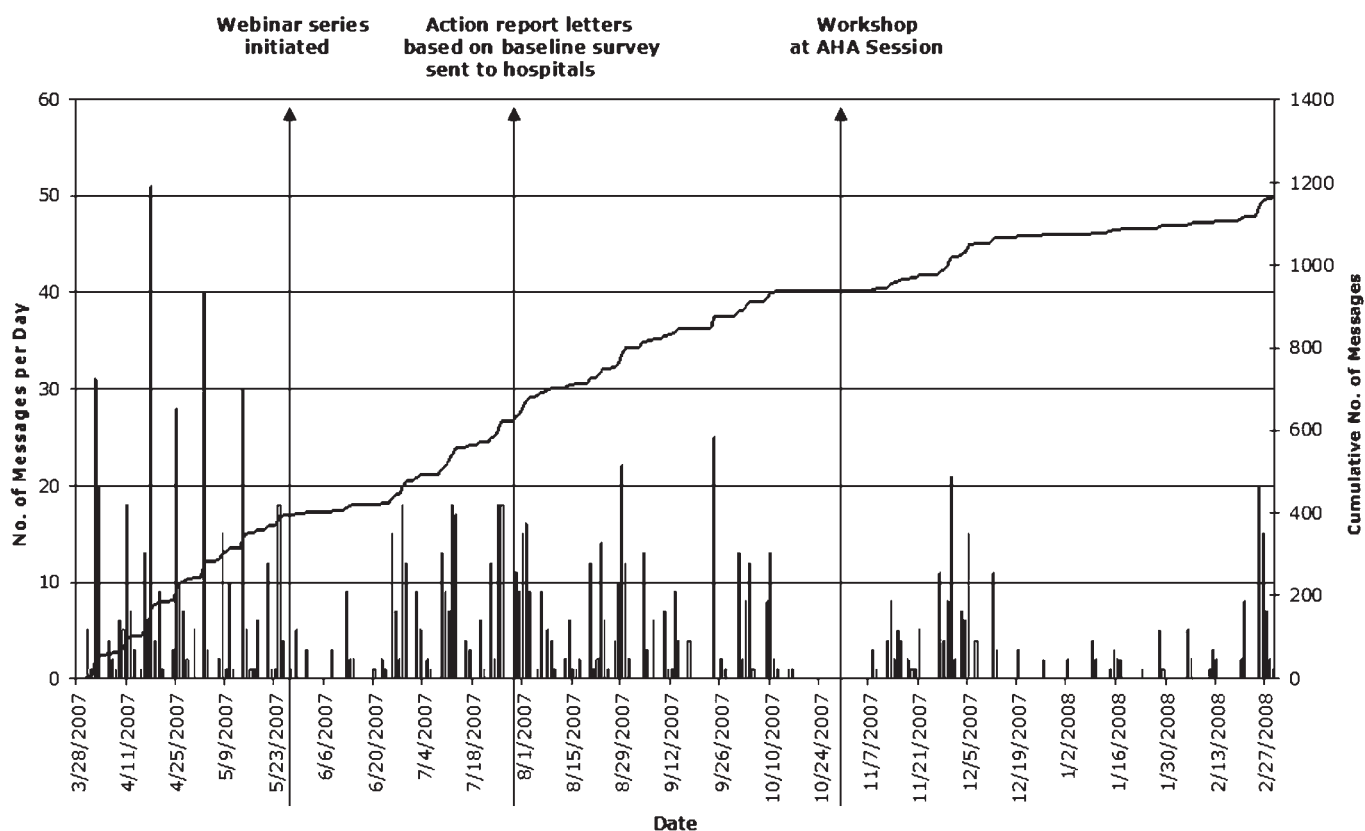

Figure 3 Number of messages per day to the D2B online community, 28 March 2007 to 29 February 2008.

52

DISCUSSION

More than half of the hospitals that enrolled in the D2B Alliance used the D2B Online Community. Of these, 52% had staff that contributed messages. This percentage is substantially higher than the 10% estimated for online communities for other populations.[6 7] The D2B Alliance did not provide incentives for use or prompt use after campaign enrollment. Thus, the willingness to use the community is striking. Some have suggested that network vibrancy can be assessed by the level of information-seeking[14]; with 79% of new messages used for information-seeking, this community would be considered vibrant. Research suggests that such vibrancy occurs when members identify with a community and its goals.[15 16] The relatively high use of the D2B Online Community may therefore reflect both its affiliation with a campaign that hospitals respected and users' shared commitment to quality improvement.

Our results suggest that hospitals are highly collaborative and responsive in this context, given that 57% of D2B Online Community messages shared information and every message that started a new topic of conversation received an average of 6.5 replies. Because multiple hospitals in the same locale joined the D2B Online Community, the volume of replies to information-seeking messages indicates that users were willing to share their knowledge with potentially competing peers on a variety of subjects. Thus, it appears that several hospitals overcame the interorganisational learning dilemma, which refers to the conflict organisations experience when they wish to participate in collective learning but fear the loss of competitive advantage.[17] Furthermore, the subjects discussed show that the online community created an opportunity for organisations to learn and share knowledge not only about reducing door-to-balloon times but also about other quality improvement goals, a positive spillover of community formation.

The discussions within the D2B Online Community suggest that many hospitals sought to use the community to fill four knowledge gaps known to challenge implementation and improvement efforts:[18–21] limited knowledge of (1) best practices, regulations and guidelines (know-what); (2) how to operationalise recommended practices in their setting (operational know-how); (3) how to measure performance and access benchmarked performance data (measurement know-how) and (4) how to motivate staff to change routines (personnel know-how). That hospitals used the online community for this purpose indicates receptivity, and even desire, to learn from peers, contrary to the 'not-invented-here syndrome'.[22] Their use also suggests that a valued feature of the quality campaign was the access it provided to a peer knowledge-sharing network via the online community and other offerings. Research had shown that quality managers believe that such external initiatives are beneficial[23]; our study indicates why these initiatives may be valued.

Our findings imply that access to a peer network was particularly valued by nurses (managers and staff). Previous research showed that quality managers perceive these individuals to be more involved in improvement activities than physicians.[23] Our finding that these individuals were the dominant contributors to the online community is consistent with these perceptions. Nurses (managers and not) serving as the conduit for information transfer is potentially beneficial because they work at the frontline of care where the information must be implemented. Their knowledge of the frontline may help implementation.[24] However, the lower status of nurses (vs physicians) may limit their ability to enact change.[25]

We did not find a statistically significant relationship between online community use and change in door-to-balloon times. This finding mirrors results from a study in the Veterans Administration showing no association between internal listserv use and improvement teams' success.[26] Despite the lack of statistical association between online community use and performance measures, users' helpfulness ratings indicate that organisations and their staff benefited from community use. Thus, it appears that use of the online community had a positive impact for users, but not with respect to our objective measure of performance. Unfortunately, we lack data about other benefits users might have experienced. We hypothesise that the benefits are intangible or not directly linked to performance as prior research has suggested that a key benefit of learning networks is social support, which may not directly translate into performance improvement, yet is valued by participants.[27] Future research will need to conduct qualitative studies to understand the scope of benefits users derive from online communities. Such research should also investigate whether there are complementary activities that should be provided to optimise the benefits of online communities.

Our finding that the number of messages was relatively high then progressively declined suggests a life cycle of community use to which system (listserv) capabilities should be matched. Community sponsors should prepare listservs and community members to receive a high volume of messages (∼200 per month) during the first 7 months of the community, and offer message receipt options that decrease the potential for email inbox overload (eg, a single email that includes all of the day's messages). Such preparation may prevent listserv failures and member frustration, which have been shown to undermine perceived system and service quality, and ultimately user satisfaction and continued participation in online communities.[28]

Although we found a greater level of online community use than studies of other communities, our results indicate that achieving a high and well-distributed level of participation in online communities for hospitals is a challenge. With 48% of D2B Alliance hospitals electing not to use the online community and discussion within the community largely driven by a small group of high-volume individuals, sponsors of future quality campaigns may need to consider methods of generating broader use for greater dissemination of the community benefits that future research identifies. For example, they might trial an opt-out approach to membership, use preliminary trust-building activities or launch the community by posting a question likely to generate responses. However, sponsors must also consider how many messages the community can receive before members disengage due to information overload.

The insights offered by this study should be considered in light of its limitations. We did not capture discussions that continued offline and therefore may have underestimated the quantity and scope of knowledge-sharing and learning fostered by the community. Second, we had no means to verify that those who reported community use but sent no messages (silent users) were truly users. Finally, this study focused on a single online community. The patterns of messages may differ for other online communities related to quality improvement. Nevertheless, identifying key patterns of use is a critical step in understanding the potential effect of online communities.

REFERENCES

1. Bradley EH, Nallamothu BK, Stern AF, *et al*. The Door-to-Balloon Alliance for Quality: who joins national collaborative efforts and why? *Jt Comm J Qual and Patient Saf* 2009;35:93–9.
2. Berwick DM, Calkins DR, McCannon CJ, *et al*. The 100 000 Lives Campaign: setting a goal and a deadline for improving health care quality. *JAMA* 2006;295:324–7.
3. McCannon CJ, Hackbarth AD, Griffin FA. Miles to go: an introduction to the 5 million lives campaign. *Jt Comm J Qual and Patient Saf* 2007;33:477–84.
4. Krumholz HM, Bradley EH, Nallamothu BK, *et al*. A campaign to improve the timeliness of primary percutaneous coronary intervention: Door-to-Balloon: an Alliance for Quality. *JACC Cardiovasc Interv* 2008;1:97–104.
5. McCannon CJ, Perla RJ. Learning networks for sustainable, large-scale improvement. *Jt Comm J Qual and Patient Saf* 2009;35:286–91.
6. Nonnecke B, Preece J. *Lurker Demographics: Counting the Silent*. Amsterdam: CHI, 2000.
7. Nonnecke B, Preece J, Andrews D. The top five reasons for lurking: improving community experience for everyone. *Comput Human Behav* 2004;20:201–23.
8. D2B: An Alliance for Quality. D2B Online Community. http://d2balliance.org/OnlineCommunity/tabid/132/Default.aspx (accessed 15 June 2008).
9. Bradley EH, Nallamothu BK, Stern AF, *et al*. Contemporary evidence: baseline data from the D2B Alliance. *BMC Res Notes* 2008;1:23.
10. American Hospital Association. *American Hospital Association Survey*. Chicago: Health Forum LLC, 2005.
11. Holsti O. *Content analysis for the social sciences and humanities*. Reading, MA: Addison-Wesley, 1969.
12. Strauss AL, Corbin J. *Basics of qualitative research: techniques, and procedures for developing grounded theory*. 2 edn. Thousand Oaks, CA: Sage Publications, 1998.
13. *Atlas*. Berlin: Scientific Software Development, 1997.
14. Dixon NM. *Common knowledge: How companies thrive by sharing what they know*. Boston: Harvard Business School Press, 2000.
15. Ardichvili A. Learning and knowledge sharing in virtual communities of practice: motivators, barriers, and enablers. *Adv Dev Human Resour* 2008:541–54.
16. Ardichvili A, Page V, Wentling T. Motivation and barriers to participation in virtual knowledge-sharing communities of practice. *J Knowledge Manage* 2003;7:64–77.
17. Larsson R, Bengtsson L, Henriksson K, *et al*. The interorganizational learning dilemma: collective knowledge development in strategic alliances. *Organ Sci* 1998;9:285–305.
18. Batalden PB, Davidoff F. What is "quality improvement" and how can it transform healthcare? *Qual Saf Health Care* 2007;16:2–3.
19. Kilo CM. Improving care through collaboration. *Pediatrics* 1999;103:384–93.
20. Garud R. On the distinction between know how, know what, and know why. In: Walsh JP, Huff AS, eds. *Advances in strategic management: organizational learning and strategic management*. London: JAI, 1997:81–101.
21. Tucker AL, Nembhard IM, Edmondson AC. Implementing New Practices: An empirical study of organizational learning in hospital intensive care units. *Manage Sci* 2007;53:894–907.
22. Katz R, Allen TJ. Investigating the Not Invented Here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D project groups. *R & D Management* 1982;12:7–19.
23. Cohen AB, Restuccia JD, Shwartz M, *et al*. A survey of hospital quality improvement activities. *Med Care Res Rev* 2008;65:571–95.
24. Field JM, Sinha KK. Applying process knowledge for yield variation reduction: a longitudinal field study. *Decision Sci* 2005;36:159–86.
25. Bunderson JS. Recognizing and utilizing expertise in work groups: a status characteristics perspective. *Adm Sci Q* 2003;48:557–91.
26. Neily J, Mills PD, Surott-Kimberly BC, *et al*. Listserv use enhances quality and safety in multisite quality improvement efforts. *Biomed Instrum Technol* 2004;38:316–21.
27. Nembhard IM. Learning and improving in quality improvement collaboratives: Which collaborative features do participants value most? *Health Serv Res* 2009;44:359–78.
28. Lin HF, Lee GG. Determinants of success for online communities: an empirical study. *Behav Inf Technol* 2006;25:479–88.

References

[1] https://www.cms.gov/NationalHealthExpendData/downloads/tables.pdf, accessed December 19, 2011

[2] http://www.brookings.edu/opinions/2010/0509_demographics_katz.aspx, accessed December 19, 2011

[3] http://www.cdc.gov/diabetes/statistics/prev/national/figpersons.htm, accessed December 19, 2011

[4] http://www.cdc.gov/NCHS/data/hestat/obesity_adult_07_08/obesity_adult_07_08.pdf, accessed December 19, 2011

[5] Egan BM, Zhao Y, Axon RN, US Trends in Prevalence, Awareness, Treatment, and Control of Hypertension, 1988-2008, *JAMA* 2010 May 26;303(20):2043-50

[6] Sackett DL, Rosenberg WM, et al. *BMJ*. Evidence based medicine: what it is and what it isn't. 1996 Jan 13;312(7023):71-2.

[7] Field MJ, Lohr KN. 1990. *Clinical Practice Guidelines: Directions for a New Program*. Washington: National Academies Press. 168 pp.

[8] Timmermans S, Mauck A. The Promises and Pitfalls of Evidence-Based Medicine. *Health Aff.* 2005 Jan-Feb;24(1):18-28.

[9] Costantini O, Papp KK, et al., Attitudes of Faculty, Housestaff, and Medical Students toward Clinical Practice Guidelines. *Acad Med.* 1999 Oct;74(10):1138-43.

[10] Charlton BG. Restoring the Balance: Evidence-based Medicine Put in Its Place. *J Eval in Clin Pract.* 1997 Apr;3(2): 87–98.

[11] McGlynn EA, Asch SM, et al. The quality of health care delivered to adults in the United States. *N Engl J Med.* 2003 Jun 26;348(26):2635-45.

[12] http://www.nhlbi.nih.gov/guidelines/hypertension/, accessed January 18, 2012

[13] http://www.nhlbi.nih.gov/guidelines/cholesterol/ , accessed January 18, 2012

[14] Centers for Disease Control and Prevention (CDC). Vital signs: prevalence, treatment, and control of hypertension--United States, 1999-2002 and 2005-2008. *MMWR.* 2011 Feb 4;60(4):103-8.

[15] Centers for Disease Control and Prevention (CDC). Vital signs: prevalence, treatment, and control of high levels of low-density lipoprotein cholesterol--United States, 1999-2002 and 2005-2008. *MMWR.* 2011 Feb 4;60(4):109-14.

[16] Balas EA, Boren SA. "Managing Clinical Knowledge for Health Care Improvement," in *Yearbook of Medical Informatics 2000: Patient- Centered Systems*, eds. Bemmel J and McCray AT. 2000. Stuttgart: Schattauer. pp. 65-70

[17] McCannon CJ, Calkins DR, Schall MW, Nazem AG. Saving 100,000 Lives in US Hospitals. *BMJ.* 2006 Jun 3;332(7553):1328-1330.

[18] Krumholz HM, Bradley EH, Nallamothu BK, Ting HH, Batchelor WB, Kline-Rogers E, Stern AF, Byrd JR, Brush JE Jr. A campaign to improve the timeliness of primary percutaneous coronary intervention: Door-to-Balloon: An Alliance for Quality.

[19] http://www.premierinc.com/safety/topics/scip/, accessed January 16, 2012

[20] Berwick DM, Calkins DR, McCannon CJ, Hackbarth AD. The 100,000 lives campaign: setting a goal and a deadline for improving health care quality. *JAMA* 2006 Jan 18;295(3):324-7.

[21] McCannon CJ, Hackbarth AD, Griffin FA. Miles to go: an introduction to the 5 Million Lives Campaign. *Jt Comm J Qual Patient Saf. 2007 Aug;33(8):477-84.*

[22] Bradley EH, Herrin J, Wang Y, Barton BA, Webster TR, Mattera JA, Roumanis SA, Curtis JP, Nallamothu BK, Magid DJ, McNamara RL, Parkosewich J, Loeb JM, Krumholz HM. Strategies for reducing the door-to-balloon time in acute myocardial infarction. *N Engl J Med*. 2006 Nov 30;355(22):2308-20.

[23] Esslinger EE, Sun C, et al. The 2010-2011 home health quality improvement national campaign. *Home Healthc Nurse.* 2011 May;29(5):298-305.

[24]Frieden TR, Berwick DM. The "Million Hearts" initiative – preventing heart attacks and strokes. *N Engl J Med*. 2011 Sep 29;365(13):e27

[25] Tucker AL, Nembhard IM, Edmondson AC. "Implementing New Practices: An Empirical Study of Organizational Learning in Hospital Intensive Care Units." HBS Working Paper No. 06-049. http://www.hbs.edu/research/pdf/06-049.pdf , accessed January 16, 2012.

[26] Nembhard IM, Nazem AG, Webster TR, Wang Y, Krumholz HM, et al. Understanding the use and impact of an online community in a national quality improvement campaign. *BMJ Qual Saf.* 2011 Jan;20(1):68-75.

[27] Bradley EH, Nallamothu BK, Stern AF, Cherlin EJ, Wang Y, et al. The door-to-balloon alliance for quality: who joins national collaborative efforts and why? *Jt Comm J Qual Patient Saf.* 2009. Feb;35(2):93-9.

[28]

http://www.d2balliance.org/D2BSustaintheGain/WhatisD2B/tabid/217/Default.aspx, accessed January 21, 2012

[29] Bradley EH, Nallamothu BK, Herrin J, Ting HH, Stern AF. National efforts to improve door-to-balloon time results from the Door-to-Balloon Alliance. *J Am Coll Cardiol.* 2009 Dec 15;54(25):2423-9.

[30] Preece J. 2000. *Online Communities: Designing Usability and Supporting Sociability*. New York: J. Wiley & Sons. 464 pp.

[31] Sproull L, Arriaga M. "Online communities." H. Bidogli, ed. *Handbook of Computer Networks, Vol. 3*. J Wiley & Sons, New York: 2007.

[32] Pew Research Center. http://pewinternet.org/Reports/2011/Social-Networking-Sites.aspx, accessed December 26, 2011

[33] Stanoevska-Slavbeva K, Schmid BF. A typology of online communities and community supporting platforms. *Proceedings of the 34th Annual Hawaii International Conference on System Science, 2001.* 2001 Jan 3-6; pp. 10

[34] Stanoevska-Slabeva K. Toward a community-oriented design of internet platforms. *Intl J of Elec Comm.* 2002 Spring;6(3):71-95.

[35] Cash JI, Konsynski BR. IS redraws competitive boundaries *Harv Bus Rev*. 1985;63(2):134-143.

[36] Plant R. Online Communities. *Tech in Soc.* 2004;26(1):51-65.

[37] Lazar J, Preece J. Classification Schema for Online Communities. *Proceedings of the 1998 Association for Information Systems, Americas Conference*. 1998; pp. 84-86.

[38] Armstrong A, Hagel J. The real value of online communities. *Harv Bus Rev*. 1996 May-Jun;74(3):134-141.

[39] Lave J, Wenger E. 1991. *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press. 138 pp.

[40] Wenger E. 1998. *Communities of practice: Learning, meaning, and identity.* Cambridge: Cambridge University Press. 342 pp.

[41] Wenger E, McDermott R, Snyder WM. 2002. *Cultivating Communities of Practice.* Boston: Harvard Business Review Press. 284 pp.

[42] Nickols F. Comparisons of various kinds of groups. Accessed January 18, 2012 at http://www.nickols.us

[43] Wenger, E. www.ewenger.com/theory, accessed January 7, 2012

[44] Orr J. 1996. *Talking About Machines: An Ethnography of a Modern Job.* Cornell University Press. 172pp.

[45] Wenger E. Knowledge management as a doughnut: Shaping your knowledge strategy through communities of practice. *Ivey Bus J*. 2004 Jan-Feb;68(519):1-8.

[46] Zhao X, Bishop MJ. Understanding and supporting online communities of practice: lessons learned from Wikipedia. *Edu Tech Res & Dev*. 2011;59(5):711-735.

[47] Garcia J, Dorohovic M. The truth about building and maintaining successful communities of practice. *Defense Acquisition Review Journal*. 2005. Accessed January 11, 2012 at http://www.dau.mil/pubscats/PubsCats/AR%20Journal/arq2005/Dorohovich-pb1.pdf

[48] Leonard D, Sensiper S. The role of tacit knowledge in group innovation. *Calif Mgmt Rev.* 1998;40(3):112-132.

[49] Biggam J. Defining knowledge: An epistemological foundation for knowledge management. *Proceedings of the 34th Annual Hawaii International Conference on System Science, 2001.* 2001 Jan 3-6; pp. 7.

[50] Bunderson JS. Recognizing and utilizing expertise in work groups: a status characteristics perspective. *Adm Sci Q* 2003;48(4):557-591.

[51] Bradley EH, Nallamothu BK, Stern AF, Byrd JR, Cherlin EJ, et al. Contemporary evidence: baseline data from the D2B Alliance. *BMC Res Notes.* 2008 Jun 11;1:23.

[52] American Hospital Association. 2006. *Fiscal Year 2005 AHA Annual Survey Database*. Chicago: Health Forum LLC.

[53] Holsti O. 1969. *Content analysis for the social sciences and humanities.* Reading, MA: Addison-Wesley. 236 pp.

[54] Strauss AL, Corbin J. 1998. *Basics of qualitative research: techniques and procedures for developing grounded theory, 2nd ed.* Thousand Oaks, CA: Sage Publications. 336 pp.