Exploring the Use of Mobile Devices for Knowledge Sharing in Healthcare: A Hospital Case Study

Completed Research Paper

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ABSTRACT

This study formulates and empirically tests a theoretical model involving factors in the use of mobile devices for knowledge sharing in hospitals. The research model is derived from two important studies, Kankanhalli et al.'s (2005a, 2005b) studies on electronic knowledge repositories, and is adapted to the healthcare context. We conduct an exploratory case study of three mobile devices in two units of a hospital. The preliminary results reveal that factors such as image, privacy, reciprocity, quality of output, resource availability and portability influence the use of these devices for knowledge sharing.

Keywords

Mobile devices, healthcare, knowledge sharing, information technology/systems.

INTRODUCTION

Mobile devices (MDs) are important IT-based solutions to facilitate knowledge sharing (KS). Different from fixed computers or nursing workstations, the use of MDs aims to provide healthcare professionals with easy access to patient and medical information at the bedside, thereby enhancing medical decisions and knowledge integration (Fontelo et al., 2003). These devices can help healthcare professionals cut down the time involved in searching for forms and knowledge at the bedside, and can reduce the risk of prescribing errors (Amarasingham et al., 2009). They can help professionals provide the best and safest care. However, as MDs become more pervasive in healthcare institutions that are embracing change, one of the biggest problems these institutions face is persuading healthcare professionals to use, and share their knowledge through, these devices. Extensive research has been devoted to understanding the factors that facilitate adoption of MDs by healthcare professionals (e.g., Lu et al. 2005; Wu et al., 2007), but the use of information technology (IT) for KS purposes involves additional factors (e.g., Kankanhalli et al. 2005; Wasko and Faraj 2005).

The literature on knowledge management (KM) in the healthcare sector reveals the highly fragmented state of medical knowledge and the need for collaboration across organizational and professional knowledge boundaries (Meijboom et al., 2004). Strong professional boundaries are also associated with the fragmentation of medical knowledge. This is associated with a gap between academic research evidence and everyday practice in healthcare settings. Therefore, there is a need to create environments in which healthcare professionals are able to easily share their knowledge. Specifically, these environments must make up-to-date knowledge accessible and available to medical practitioners, and support the practice of evidence-based medicine (Scott et al., 2009). Healthcare IT systems, especially mobile tools, can enhance such environments. However, many healthcare professionals remain reluctant to embed these tools in their medical practices (e.g. Pirnejad et al., 2008; Protti et al., 2007). Much of their work must be carried out quickly, and is completed away from their offices, so the need to frequently interact with technology, especially fixed workstations, can be resisted. Lack of attention as to how knowledge sharing among healthcare professionals will be affected by specific technologies appears to be a weakness of many KM initiatives (Haux 2006; Mead, 2006). Therefore, the objectives of this exploratory research are to:

1. *Explore factors enabling or inhibiting knowledge sharing through mobile devices in healthcare settings; and*

2. *Understand how healthcare professionals using mobile devices share their knowledge as they practice medicine.*

Next, we present background literature on KS and the use of MDs for KS in healthcare settings. We develop and qualitatively test a conceptual model in an embedded case study design involving the analysis of three MDs in two hospital units. We close by presenting our conclusions and ideas for researchers and practitioners.

LITERATURE REVIEW

Knowledge Sharing

KS is seen as an "exchange where one party gives some knowledge that s/he has (explicit or tacit) to another party (a person, a group, or a repository)" (Staples and Webster 2008, p. 619). Our study examines the sharing of explicit knowledge between healthcare providers, or between these providers and IT systems. KS is considered as a bi-directional act of contributing and seeking knowledge at different points in time (Kankanhalli et al. 2005a). Hence, IT-based tools are introduced into hospitals so that professionals can seek and contribute knowledge (e.g., involving a colleague or electronic repository) leveraging these tools.

In the healthcare literature, KS is described as a process that makes relevant information accessible and available to end users (e.g., physicians, nurses, and patients). For example, in providing treatments for patients, there is a need for ongoing KS between healthcare professionals to ensure that patients receive the right treatments at the right time (Hansen et al., 1999). Although these professionals are aware of the importance of KS and the use of IT as an enabler of healthcare processes, as described earlier, some remain reluctant to use the KS tools. Davenport and Glaser (2002) claim that one of the challenges is dealing with the autonomy of physicians and their resistance to computer use in their work. They posit that "[physicians] enjoy high levels of autonomy; they are sufficiently powerful that the organizations they work for are reluctant to tinker with their work processes; and, perhaps most important, they do most of their work away from a computer screen" (p. 111).

Mobile Communication in Healthcare

Mobile devices have become a solution to the nomadic work requirements of healthcare professionals. Information and communication needs of these professionals at various locations and at different times are difficult to satisfy. Although hospitals have installed computer workstations, space for these stations is limited. Also, time is critical in the medical profession. For instance, physicians have little time to spend with patients during rounds; and going back and forth to a computer workstation adds time to their practice, and can limit the growth of evidence-based medicine (Goldstein, 2010). Mobile devices seem to offer a solution to these problems; however, the technical characteristics of the devices (e.g., small size, poor physical display, poor connectivity, and limited battery life) and lack of organizational readiness for change and executive support are hampering their availability and use (Ammenwerth et al., 2000; Fontelo et al., 2003; Lu et al., 2005).

THEORETICAL BACKGROUND

The use of MDs for KS involves: (1) the user's motivation for KS, and (2) the user's acceptance and adoption of the technology (e.g., MDs) as an enabler of the KS process (Ba et al., 2001). To investigate this, we use and adapt Kankanhalli et al.'s (2005a, 2005b) models. Drawing from the Social Exchange Theory (SET) and Theory of Planned Behavior (TPB), these scholars examined the costs and benefits of knowledge sharing using electronic knowledge repositories. Cost and benefit factors have been seen as barriers and motivators for knowledge exchange (Ba et al., 2001; Constant et al., 1994; Hall, 2001; Wasko and Faraj, 2000). Social exchange theorists have suggested that by increasing the benefits (or motivators) and reducing the costs (inhibitors) of KS, individuals can be encouraged to share their knowledge. Some of the costs and benefits are affected by the specifics of the technology used as a medium for the exchange. These authors suggest that the perceived usefulness and ease of use of the technology also impact KS. Table 1 summarizes the key factors identified in previous studies that are relevant in healthcare[1].

[1] A panel of experts in the healthcare industry examined the factors and rated a subset as being more applicable in this context. Details of this pilot study are found in the methodology section.

Factor	Exchange	Relation to KS	List of Sources
Codification effort	Time and cost associated with sharing knowledge.	–	Ba et al. (2001); Kankanhalli et al. (2005a, 2000b); Taylor and Todd (1995)
Image	The perception that knowledge sharing enhances one's reputation or image.	+	Hall (2001); Kankanhalli et al. (2005b); Wasko & Faraj (2005)
Reciprocity	The belief that contributing knowledge leads to future requests for knowledge being met.	+	Kankanhalli et al. (2005a); Wasko & Faraj (2005)
Quality of output	The perceived quality of the output provided by an information system in terms of relevance, reliability, and timeliness of knowledge.	+	Huang et al. (1998); Kankanhalli et al. (2005a); Taylor and Todd (1995)
Resource availability	The time and opportunities to access the technology.	+	Culnan (1984); Kankanhalli et al. (2005a) Taylor and Todd (1995)

Table 1. Key Factors Influencing Knowledge Sharing in Healthcare

Using this literature, and the SET and TPB theoretical lenses, we derive the following propositions:

P1: The more effort required for codifying and retrieving knowledge to and from MDs, the less likely healthcare professionals will share knowledge through these devices.

P2: Healthcare professionals who perceive that the use of MDs during their practice will diminish their image will share less knowledge through these devices.

P3: The greater the expectation of reciprocity, the more likely healthcare professionals will share their knowledge through mobile devices.

P4: The greater the perceived quality of information available through MDs, the more likely will healthcare professionals share knowledge through the devices.

P5: The higher the resource availability of MDs, the more likely will healthcare professionals share knowledge through the devices.

CONCEPTUAL MODEL

In addition to these proposed factors, we add two others to the model: portability and privacy. The degree of portability of a technology has been related to its use and effectiveness (Garfield, 2005). Today's organizational work-life reveals the "nomadic information environments" and the highly mobile nature of current professions (Lyytinen and Yoo 2001). MDs are considered a key technological element in an integrated healthcare system (Fontello et al., 2003; Protti, 2007). Studies promoting evidence-based medicine claim that the use of mobile communication devices is a step towards the goal of bringing that evidence to the bedside (Westbrook et al., 2003). Studies have shown that convenient access to medical information at the point of care increases the likelihood that clinicians will utilize these devices as part of their daily workflow (Westbrook et al. 2004). Therefore, we expect that the extent to which a mobile device supports the "nomadicity" of the healthcare profession will be positively associated with the extent to which healthcare professionals use these devices for knowledge sharing purposes. Thus, we expect that:

P6: The portability of a mobile device will positively affect knowledge sharing through the device.

Storage of, and access to, electronic patient information have raised issues of confidentiality in healthcare settings. Although there is a call for integrated healthcare systems, governmental and healthcare institutions are concerned with the potential risks of exchanging electronic patient information (Veronesi, 1999). These concerns range from issues of data ownership to the accountability for handling confidential information over an inter- or intra- network (Milton, 2009). Healthcare professionals are concerned about possibly breaching patient confidentiality. As a result, some practitioners are reluctant to use mobile devices in their medical practices. A post-implementation study of a wireless voice recognition technology in a hospital found that IT was underused because of privacy concerns (Vandenkerkhof et al., 2009). Therefore, we expect that concerns about privacy issues may inhibit KS through mobile devices,

P7: The perceived risk of breaching confidentiality will negatively affect knowledge sharing through a mobile device.

The conceptual model and associated propositions are described in Figure 1. See also Table 1.

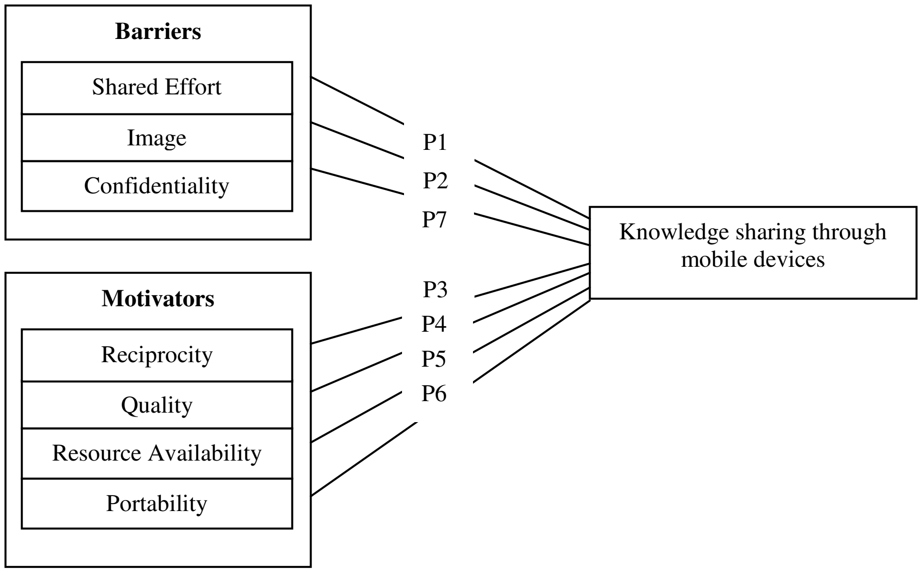

Figure 1. Conceptual Model and Propositions

SETTING AND DATA COLLECTION

Given the exploratory nature of this research, and the context of the study (e.g., healthcare), an embedded case study is suitable (Yin 2009). The research setting is a 456-bed acute-care facility providing health services to approximately 500,000 people in Southeastern Ontario, Canada. This facility is a teaching hospital affiliated with the local university. The study settings included critical care and anesthesiology and peri-operative medicine because these areas had introduced mobile technologies. This research site became available because of the third author's role at the hospital as an attending physician, head of one of the MD projects (i.e., the Tablet Personal Computer) and its specialized information system (e.g., the Acute Pain Management System). We studied three MDs: the Tablet Personal Computer (TPC), a Workstation On Wheels (WOW), and a voice recognition device (Vocera®). These MDs allowed us to explore theoretically and practically the KS practices of healthcare professionals, and their decisions to use or not use MDs within different areas in a single organizational setting (Gurteen 1998; Hansen et al. 1999).

Data collection included participant observation (by the first and third authors), field notes, and semi-structured interviews. A pilot study was first conducted to refine the field instruments (interview guides, etc.). Three healthcare professionals considered technology champions of the three MDs and two academic experts in information systems reviewed and modified the initial questions. Semi-structured interviews were conducted over a period of four months. They were used to gather information on: a) the type of knowledge shared through the mobile device, the purposes for, and frequency with which, the device was used[2], and the user's familiarity with mobile devices in general; b) interviewee perceptions of the influence of each of the factors identified in the conceptual model; and c) other information offered by the interviewee that s/he considered relevant. Examples of questions[3] are as follows:

- For what purposes do you use the *MD (e.g., TPC, WOW (sometimes referred to as a Computer on wheels or COW), Vocera (a Voice Over Internet Protocol communication device))?* (Please describe a situation in which you would use the *MD*; please describe a situation where you could use the *MD* but would not want to.)
- What type of information do you enter and look for in the *MD* (e.g., patient-related information, process-related information, medical information)?

We sought and received research ethics clearance, and then conducted 12 interviews, lasting 30-45 minutes each, and distributed as follows: TPC - three attending physicians and a nurse practitioner, WOW - two attending physicians and a resident, Vocera - three nurses, a support worker, and the chief information manager. Interviews were recorded, transcribed, and analyzed by the first author. Data analyses and findings were discussed with and/or verified by the second and third authors. Field notes and e-mail exchanges between the first author and study participants complemented the interview data collection. A complementary survey was also conducted but is not described in this paper because of space constraints.

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[2] The use of the device is considered a proxy variable to measure the extent of KS (see Kankanhalli et al. (2005a, 2005b) for more details).

[3] Due to space limitations, a complete interview guide has not been provided but is available from the authors.

DATA ANALYSIS: NARRATIVE FOR THREE MOBILE DEVICES

The Tablet Personal Computer (TPC)

Figure 2. TPC

The TPC is used by attending physicians, residents and nurse practitioners in the hospital's Anesthesiology and Perioperative setting. The TPC is a portable personal computer equipped with a 12'' touchscreen. Healthcare professionals can enter or retrieve information from the device by using either the stylus pen on the screen keyboard or an external keyboard attached to the base body (Figure 2). The device is mainly used in the perioperative setting to assess patients' acute pain in pre- and post-operative phases through the Acute Pain Management System (APMS). Prior to the TPC, the APMS was accessed through Personal Digital Assistants (PDAs). However, physicians complained about the small screen and keyboard size of the PDAs, so, a year later, PDAs were replaced by TPCs. The APMS software provides the healthcare professional with a (1) checklist template for pain assessment, (2) information on side-effect therapy, (3) drug usage, (4) notable events, (5) consultations, (6) lab results, (7) pharmacy, (8) imaging, and (9) billing. APMS "consults" are entered into the APMS application, available via the hospital intranet, either through the TPC or a nursing workstation.

The field notes, direct observation and interviews revealed that, although the TPC provides effective medical decision support, usage of the device is very low. Arguably no more than 20 percent of healthcare professionals choose to use the TPC. Non-users bring their notes on a clipboard from their rounds and walk to the nearest nursing workstation at which they enter the information. Low TPC usage has affected the level of detailed information available for pain assessments in the perioperative setting, even via the system. A physician commented:

"*Sometimes, you click on the consultation assessment and you don't find a thorough assessment from the previous day*" (active TPC user expressing frustration that non-TPC user information in the APMS is less complete).

This limited information has affected the ability of the TPC device to support evidence-based medicine. The main reasons reported for the lack of usage were initial negative experiences with the device as problems were being corrected as it was being implemented, and user discomfort with the APMS and TPC project. Some non-users referred to the system and device as *"[doctor's name]'s project*". There was little encouragement from the hospital management or other professionals to use the system. Respondents also pointed out the limited number of available devices and described technical challenges (e.g., intermittent wireless connectivity). Table 2 summarizes the interview findings and reveals that image, reciprocity, quality of information output, resource availability and portability are crucial factors for successful KS through the TPC device.

The Workstation On Wheels (WOW)

The Workstation On Wheels (WOW), also known as a computer on wheels, is basically a notebook placed on a mobile cart. The device used in the intensive care unit (ICU) is a StyleView® 19" LCD widescreen cart with a drawer (see Figure 3). As a trial technology, the device was introduced in the ICU to facilitate storage and retrieval of patient-related information at the bedside. The MD was perceived as a solution to eliminate frequent walking to, and logging in and out of the computer at, the nursing workstation. The system could be transported alongside the healthcare professional who could stay logged in. Due to early stage of the hospital's Electronic Medical Records (EMR), the Patient Care Information System (PCS) did not provide data entry capability for healthcare professionals. Thus, they used the device simply to access test and lab results, x-rays, pharmacy information, and previous assessments. The device was also connected to the Internet; so some physicians used it to access medical research in an up-to-date electronic medical repository.

Figure 3 WOW

Despite its limited availability (i.e., a single device for the entire unit), the WOW was often used during rounds. Most user complaints concerned issues related to the "hybrid" EMR in the hospital. A physician commented, "*I have to go back and forth from the [paper] chart to the WOW. For previous admissions, I go to the computer but for the current, I need the chart*". Current patient information needed to be scanned before uploading it to the PCS. However, this was not a deterrent to knowledge seeking. Physicians valued the content of the PCS and the opportunity to access an *up-to-date* knowledge repository at the patient's bedside.

The portability attribute of the WOW was also a crucial factor. Physicians spoke of their efficiency gains and increased medical and patient-related information searching. One stated, "*If I don't have the WOW, it is less likely that I look for a patient's past lab results. I can do it if I log into the PCS from the nursing workstation, but it will take me longer…I need to log in and out for every patient*". Table 2 highlights key findings regarding KS using the WOW.

The Voice Recognition Device (Vocera)

Figure 4 Vocera

The portable voice recognition system was a wireless communication device developed by Vocera Inc. The software platform ran on a standard Microsoft Windows server that housed call management, call connections, and user profiles. Vocera was introduced with the intention of streamlining nurses and allied health group's communications. In the ICU, the interviewees reported that they used the device for emergency situations (e.g., to ask for help), to call respiratory technicians, to look for equipment, to seek and confirm medication doses, and to arrange break times with co-workers. They valued its small size and portability.

Vocera employed simple voice commands (i.e., "call Charles Jones"; "record a message for Tech Support"). Interviewees had no difficulties with using the device, but complained about technical issues, stating for example, "*Vocera can be very frustrating sometimes because it misinterprets what you said*". As a result, some users thought that telephones and pagers were still necessary in the unit. Confidentiality was another concern for Vocera users. The risk of breaching patient confidentiality decreased the use of this device. Nurses, for instance, were concerned about divulging patient-identifiable information when using this device because individuals, other than the target information recipient, could often hear what was being said.

Table 2 presents a summary of our findings regarding KS barriers and motivators, across the three mobile technologies.

Factor	**Overall Findings**	**Sample Evidence**
Effort	KS is affected negatively by technical problems (e.g., wireless availability) and poor information system design in all three MD cases.	"*The Tablet is very slow.*" (TPC) "[the PCS] *has an unfriendly interface.*" (WOW) "The software interpretation of commands often *does not work*; "blah blah" is sometimes more effective than log me out." (Vocera)
Image	Physicians do not perceive the use of MDs to enhance their image but nurse practitioners perceive enhanced professional status when using the TPC.	"*Physicians do not usually ask questions to nurses, but because I'm one of the most experienced [TPC] users, they have to call me when they face issues with the device.*" (TPC)
Reciprocity	Physicians report their expectations of finding comprehensive consultation information in the APMS. When this is not the case, they are frustrated.	"*Sometimes, you click on the consultation assessment, and you don't find a thorough assessment from the previous day.*" (TPC)
Quality	TPC and WOW users agree on the importance of the information accessed through the devices for their medical decisions.	*"Although it sometimes takes a little bit longer, I use the WOW all the time because I need to know the X-rays and lab results before seeing a patient"*
Resource Availability	This factor is perceived differently by a TPC user and non-user. Availability affects knowledge sharing.	"*There is always a Tablet available when I need it. Only a few times, I have not used it because the system is down." (TPC user)* *"It is a problem when your rounds are on the weekend because the Tablets are usually locked up in the department." (Non-user)*
Portability	Device portability is valued by all MD users but is perceived to be critical for TPC and WOW users.	"*The portability of the Tablet is the key issue for me because my office is where I stand.*" (TPC) *"If I don't have the WOW, it is less likely that I look for a patient's past lab results…it takes longer from the nursing workstation."*
Confidentiality	The possibility of breaching patient confidentiality is a negative factor for KS in the Vocera case.	"*We are trained about not revealing patient information; but sometimes you forget. Confidentiality can become a potential problem with Vocera.*"

Table 2. Summary of Interview Findings

DISCUSSION AND CONCLUSION

By using previous KS models, we formulate and test a series of propositions in an exploratory qualitative study that identifies potential factors influencing the use of mobile devices for KS in healthcare environments. Our preliminary results suggest that MDs support the mobile nature of medical practice and have the potential to promote knowledge integration. By accessing medical knowledge resources and updated patient information at the bedside, physicians and nurses can enhance their medical decisions, thereby offering safer and better quality care. However, the successful implementation of these technologies for KS purposes depends on several organizational, technical and behavioral factors and is influenced by the device's technological and functional capabilities. In healthcare settings in which there is not organizational readiness or senior management support for change, or the willingness or ability to make costly technology and MD investments, the use of MDs for KS will be hindered.

Our study results reveal that image, confidentiality, reciprocity, quality of output, resource availability and portability are factors that impact individual healthcare professionals' decisions to share knowledge through all the MDs we examined. However, the extent to which the factors enable or hinder KS by physicians and nurses varies by the technology; for example, all the previous factors accept confidentiality (the information was encrypted) appeared to influence TPC usage, while for the WOW and Vocera, quality of the output, portability and confidentiality seemed most important. For all three devices, the robustness of wireless infrastructures, the technical attributes of the device, and the amount of training provided to users influenced the quality of the output and the required effort to use the MDs. (Respondents indicated that limited training had been provided.) Some users opted to use a fixed computer instead of MDs because they did not find the devices reliable or satisfactory. A common complaint, related to the quality of the output, was the low screen resolution and limited ability of the TPC and WOW devices to display sharp images (e.g., x-rays). This reduced the perceived value of the technology (McAfee, 2006). User complaints about "poor Internet connectivity," and negative "initial experiences that turned them off," suggested that healthcare institutions should ensure the technology quality is high and "system bugs" are removed before introducing MDs.

We observed that non-use could have a ripple effect. When healthcare professionals became non-users of devices (e.g., due to early negative experiences or to perceived lack of top management support), their non-use reduced the image associated with using the technology, and even more importantly, the comprehensiveness of the patient information. Other users then reported, that although the portability of the devices facilitated detailed patient assessments, they did not find the same level of detail available from other professionals' assessments, and were frustrated. This resulted in a lack of interest in continuing to use the devices. The lack of reciprocity served as a deterrent, and the use of the MD spiraled downwards.

The degree of physical portability was also an important factor. On the negative side, *having to carry the device* could hamper its use. In this way, paradoxically, the high portability of the TPC, for instance, could hinder its adoption. Some users reported that a practical solution would be to place the device on a mobile cart, thereby converting it to a WOW. Thus, although portability generally seemed positively related to use, different users desired different degrees of portability, and portability could also act as a deterrent.

Confidentiality was more critical for a communication device such as Vocera than for the other two mobile devices. Vocera did not allow the storage of information in the form of a repository. Thus, the risk of breaching patient confidentiality was not related to a potential misuse of electronic medical records, but to verbal divulging of confidential information. Users perceived this factor as detrimental for Vocera usage. For the other two devices, users trusted the encryption software that protected the electronic medical records, and were not deterred by confidentiality concerns.

In closing, we acknowledge that our study was exploratory; it was limited to a single hospital in Canada and relied largely on the subjective views of interviewees. However, we expect that other researchers will be able to test our proposed model more rigorously in other healthcare contexts and using other technologies. This initial qualitative analysis provides evidence to support the importance of image, privacy, reciprocity, quality, resource availability and portability in mobile solutions for knowledge sharing purposes. In this way, we highlight key factors to be considered when introducing mobile technologies as important tools in the practice of evidence-based medicine.

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