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Review

Review

How does medical scribes' work inform development of speech-based clinical documentation technologies? A systematic review

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ABSTRACT

Objective: Use of medical scribes reduces clinician burnout by sharing the burden of clinical documentation. However, medical scribes are cost-prohibitive for most settings, prompting a growing interest in developing ambient, speech-based technologies capable of automatically generating clinical documentation based on patient–provider conversation. Through a systematic review, we aimed to develop a thorough understanding of the work performed by medical scribes in order to inform the design of such technologies.
Materials and Methods: Relevant articles retrieved by searching in multiple literature databases. We conducted the screening process following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) in guidelines, and then analyzed the data using qualitative methods to identify recurring themes.
Results: The literature search returned 854 results, 65 of which met the inclusion criteria. We found that there is significant variation in scribe expectations and responsibilities across healthcare organizations; scribes also frequently adapt their work based on the provider's style and preferences. Further, scribes' job extends far beyond capturing conversation in the exam room; they also actively interact with patients and the care team and integrate data from other sources such as prior charts and lab test results.
Discussion: The results of this study provide several implications for designing technologies that can generate clinical documentation based on naturalistic conversations taking place in the exam room. First, a one-size-fits-all solution will be unlikely to work because of the significant variation in scribe work. Second, technology designers need to be aware of the limited role that their solution can fulfill. Third, to produce comprehensive clinical documentation, such technologies will likely have to incorporate information beyond the exam room conversation. Finally, issues of patient consent and privacy have yet to be adequately addressed, which could become paramount barriers to implementing such technologies in realistic clinical settings.
Conclusions: Medical scribes perform complex and delicate work. Further research is needed to better understand their roles in a clinical setting in order to inform the development of speech-based clinical documentation technologies.

Key words: Medical Scribe, Health Information Technology, Speech Recognition Software [L01.224.900.889], Professional Burnout [C24.580.500], Workflow [L01.906.893], Documentation [L01.453.245], Electronic Health Records [E05.318.308.940.968.625.500]

INTRODUCTION

Background and Significance

As a result of policy mandates and financial incentives, the use of electronic health records (EHRs) in U.S. hospitals and clinics has become nearly ubiquitous. According to recent statistics reported by the U.S. Office of the National Coordinator for Health Information Technology, 96% of nonfederal acute care hospitals and 80% of office-based physicians had adopted certified EHRs in 2017.[1,2]

While the use of EHR brings about many benefits, their rapid adoption has also been associated with a wide range of unintended adverse consequences, such as workflow disruption,[3] diminished quality of patient–provider interaction,[4] and new types of medical errors.[5] In addition, many studies have reported that, in the post-EHR era, clinicians spend substantially more time practicing "desktop medicine."[6] For example, research based on EHR logs or time and motion observations has shown that many clinicians, after meeting documentation requirements, were only able to allocate a quarter of their time to direct patient care activities,[6–8] with 1 study noting that primary care physicians spend nearly 6 hours a day working with the computer.[9] The increasing documentation burden is believed to be a key factor contributing to clinician burnout,[10] which has been found to be associated with anxiety and stress, job dysfunction, and potential patient harms.[11–15] Indeed, in the 2016 21st Century Cures Act, U.S. Congress specifically directed the U.S. Department of Health and Human Services to develop strategies to "reduce EHR-related burdens that affect care delivery."[16]

Among healthcare organizations (HCOs), one popularly used approach to reducing clinician burnout is to employ medical scribes. These could be clinically trained personnel (eg, nurses and medical assistants), or individuals with no formal medical training.[17] As individuals "hired to chart patient–clinician encounters in real time," medical scribes' work helps to share much of the burden associated with documenting in the EHR from healthcare practitioners.[18] Several studies have shown that medical scribes could contribute to higher patient volume,[19,20] increased revenue,[21–23] and better patient and provider satisfaction.[20,24,25] As a result, the workforce of medical scribes in the United States has grown substantively in the past few years. According to the American College of Medical Scribe Specialists (ACMSS), the number of medical scribes employed in U.S. hospitals and clinics has been doubling annually since 2014, with the industry expecting "[its] ranks to swell to 1 00 000 by 2020."[26]

Medical scribes are however cost-prohibitive for most healthcare environments. Besides wages, employment of scribes would also incur additional costs associated with recruitment, training, and management,[23] limiting their affordability to only few settings such as specialty clinics and emergency departments.[21–23] Therefore, researchers and technology companies have started to explore the feasibility of using technology-based solutions to provide medical scribing, hereafter referred to as "digital scribes."[27,28] It should be noted that digital scribes discussed in this article differ from the existing automatic speech recognition–based solutions, such as Dragon Medical (Nuance, Burlington, MA), that offer merely 1-on-1 dictation capability to facilitate entering data into computerized systems. In contrast, conservation-based, ambiently listening systems seek to emulate the key function of human medical scribes by capturing clinically relevant information in the background while a clinician is conducting a patient interview in the exam room.[27]

There is currently a growing interest in developing such technologies. For example, Google evaluated an ambient automatic speech recognition–based approach to transcribing patient–physician conversation[29] and later assessed the feasibility of extracting structured information (eg, symptoms) from the transcripts.[30,31] More recently, other technology companies such as Microsoft,[32] Amazon,[33] Nuance,[34] and Cerner[35] have also announced similar efforts aimed to create digital scribing solutions.

Despite this great interest, the complex environment of clinical practice presents many potential challenges that need to be overcome for such technologies to be successful. For example, Coiera et al[27] and Quiroz et al[36] speculated on barriers to develop and implement digital scribes. They noted issues that may occur in real-world clinical settings such as poor quality of audio recordings, difficulties in inducing topic structure from conversational data, and generating clinically meaningful documentation. Building on Coiera et al's work, this systematic review study was specifically conducted on medical scribes—the human analogue of ambient speech-based documentation technologies—in order to further understand the challenges that may be associated with the implementation of digital scribing tools, as well as to offer implications for proper design.

OBJECTIVE

The primary objective of this study was to derive insights into informing future efforts in developing speech-based digital scribing solutions. In doing so, we also sought to develop a comprehensive conceptual framework that characterizes medical scribes' work, work environment, and their interactions with the provider, the patient, and other members of the care team.

MATERIALS AND METHODS

Inclusion and exclusion criteria

Our literature search focused on peer-reviewed articles that describe the work performed by medical scribes and how they are trained, certified, or evaluated. We included articles reporting empirical research as well as commentaries and opinion pieces, as long as they contained pertinent information. We excluded articles that analyzed only the outcomes of medical scribing (eg, productivity, cost-benefit analyses) and did not provide any description on medical scribes' roles and duties. We reviewed all articles published in English and before October 2019, when our literature search was conducted.

Search strategy

We searched multiple literature databases including PubMed, Web of Science, Scopus, ProQuest, EBSCOhost, and the ACM Digital Library. Search terms included *medical scribes* and *physician scribes* as well as their variants such as *medical scribing*. The complete search term list is provided in Supplementary Information File 1.

Screening, data extraction, and data analysis

The literature search identified 1409 potentially relevant articles: PubMed (n = 27), Web of Science (n = 173), Scopus (n = 213), ProQuest (n = 414), EBSCOhost (n = 581), and the ACM Digital Library (n = 1). We added 19 additional articles from citation analysis. We also removed duplicated records returned from different literature databases. With the resultant dataset, 2 authors (B.T. and C.L.) conducted an initial screening based on title and abstract, excluding clearly irrelevant ones such as those related to biblical

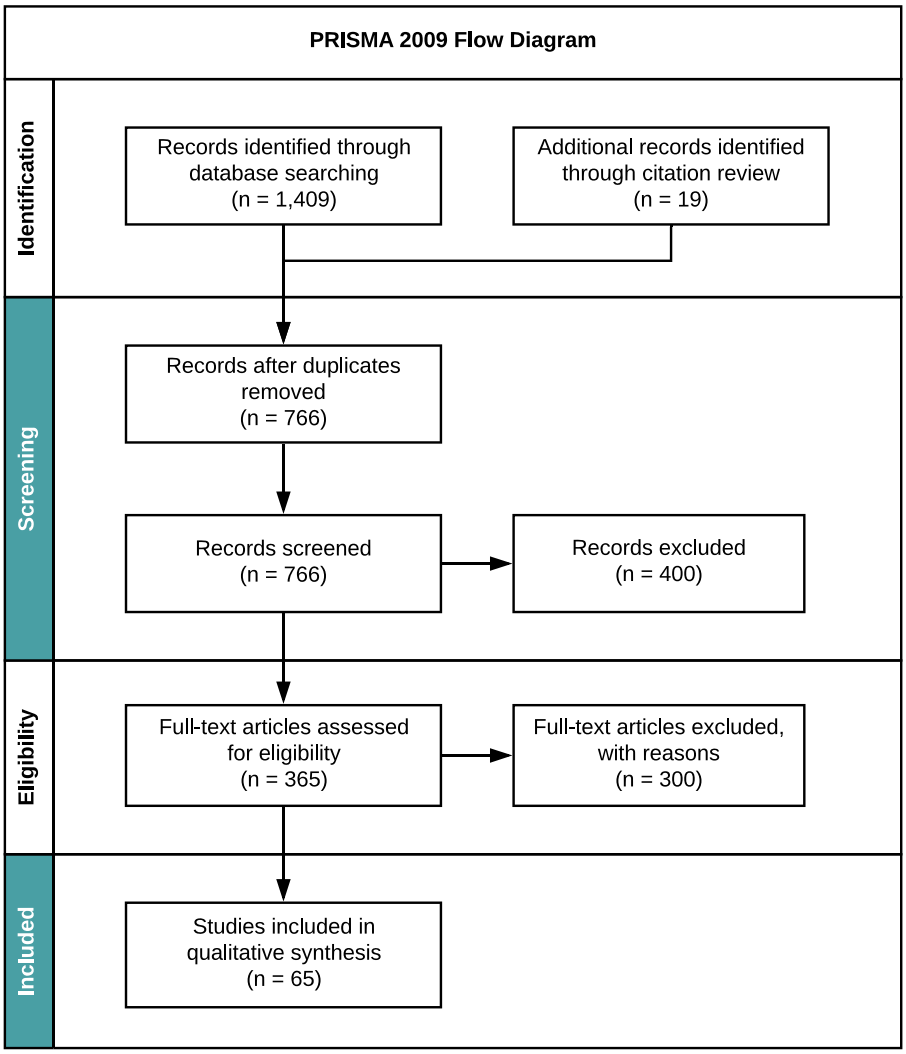

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) flow diagram.

scribes. The interrater agreement rate was high (Cohen's Kappa = 0.94). The disagreements were subsequently resolved through consensus development meetings.

The second round of screening involved full-text review jointly conducted by 2 authors (B.D.T. and Y.C.). The interrater agreement rate was similarly high (Cohen's kappa = 0.93). Based on the results, we excluded 253 articles that did not meet our inclusion criteria. This article screening and selection process is depicted in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) flow diagram shown in Figure 1.

For each of the remaining 65 articles, the first author (B.D.T.) extracted key information relevant to this review such as year of publication, study design, empirical setting, and descriptions of medical scribes' roles or duties, a random sample of which were examined independently by another author (Y.C.). Disagreements were resolved through consensus development. We then applied qualitative content analysis to the extracted results.[37] When coding the data, we used the in vivo approach, a practice that assigns labels using short words or phrases taken from the data.[37] From these labels, 2 authors (B.D.T. and K.Z.) identified emergent themes inductively, using a constant comparison method with memos. The original data extraction table is included in Supplementary Information File 3.

RESULTS

General characteristics of the articles reviewed

Of the 65 articles reviewed, 45 reported original empirical research. The rest consist of 1 meta-analysis, 2 reviews, 14 commentaries and opinion pieces, and 2 guideline documents (eg, the Joint Commission recommendation for working with medical scribes). Among the empirical studies, emergency medicine (n = 23) is most often represented, followed by internal medicine (n = 6), family medicine (n = 6), cardiology (n = 3), urology (3 n =), dermatology (n = 2), geriatrics (n = 2), surgery (n = 2), ophthalmology (n = 2), orthopedics (n = 1), hematology and oncology (n = 1), and obstetrics-gynecology (n = 1). Of note is that this distribution likely does not reflect how commonly different specialties employ medical scribes; instead, it only reflects the number of relevant studies that met our inclusion criteria.

Of the 65 articles that we reviewed, a majority were based on research conducted in the United States; 7 were conducted in Australia

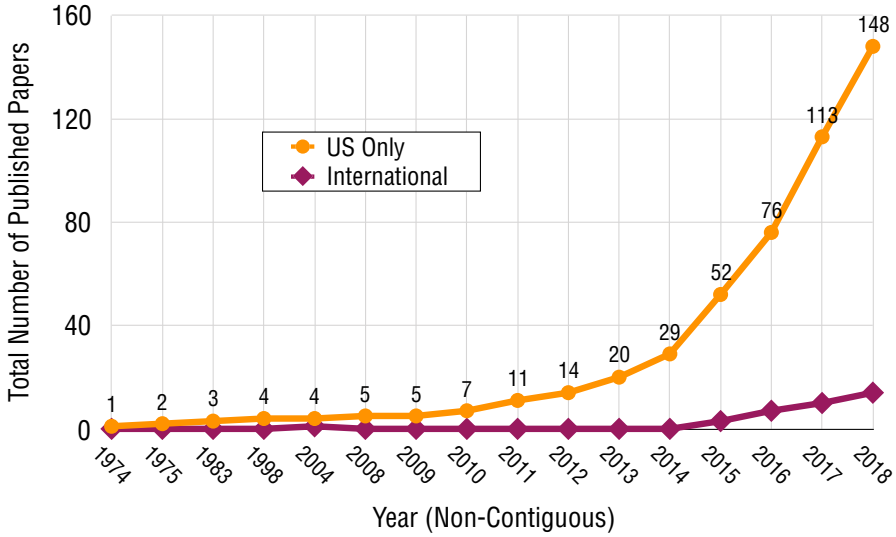

Figure 2. Longitudinal trend based on the volume of publications relevant to medical scribing.

and 1 was conducted in in Canada. We included articles published in non-U.S. contexts because they provide useful general insights into how medical scribes work; for findings that may not apply to the United States, we discuss them specifically in this article.

Of these articles, we identified 3 that focused on clinical staff who were trained to perform additional scribing duties[38–40]; the vast majority of the other articles described medial scribes who did not have formal medical training. Owing to the expanded skill set possessed by those "clinical medical scribes," the nature of their work may differ from typical medical scribes. In this study, we included both scribe types but analyzed them differently when there was a clear distinction identified in the descriptions of their work.

Longitudinal trend based on the volume of publications

To examine the volume of published work on medical scribes over time, we plotted the number of relevant articles by year up to 2018, as shown in Figure 2. Note that in this analysis, we included all relevant articles identified from the initial round of literature screening, without removing those that do not contain pertinent descriptions on medical scribes' work, as we sought to include the literature on medical scribes in its entirety, even if some articles do not meet the inclusion criteria of this particular review.

As shown in Figure 2, overall, the volume of relevant articles has increased substantially in recent years. There also appears to be a discernible time divide around 2010 and 2011, after which the rate of this increase became much higher. Further, it appears that this pattern applies only to the articles published in the U.S. context but not to research conducted internationally.

Conceptual model of medical scribing

Through analyzing common characteristics that have been repeatedly reported in the literature, we developed a conceptual model to comprehensively describe medical scribes' training, work, and work environment. This model is organized along the following 5 key dimensions:

1. **Training, Certification, and Management:** This dimension concerns the processes of training, certifying, and managing medical scribes, either by professional scribing companies (eg, ScribeAmerica) or in-house by the employing HCOs.
2. **Task and Expectation:** This dimension captures key tasks that medical scribes perform, including but not limited to scribing patient–provider conversations, and expectations for their work by the provider and by the other members of the care team.
3. **Interaction and Workflow:** Scribing work involves complex interactions with a multitude of actors such as patients, providers, medical assistants, and nurses. This dimension characterizes the nature of such interactions and the workflow by which these activities are conducted.
4. **Data Source, Content, and Structure:** This dimension describes how medical scribes assemble data from various sources (inside or outside the exam room), organize the data according to prescribed formats (eg, SOAP [Subjective, Objective, Assessment and Plan]), and enter the data into the EHR or other clinical information systems.
5. **Supporting Technology and Artifact:** Medical scribes often use software tools (eg, word processors, spreadsheets) or artifacts (eg, paper and clipboards) to facilitate transitory storage of information as memory aids. This dimension captures the array of such software tools and artifacts commonly used in scribing practice.

This conceptual model, which we refer to as the Work Model of Medical Scribe, is illustrated in Figure 3. In the following sections, we present our findings according to each of the model dimensions.

Training, certification, and management

Training of scribes

Most medical scribes receive formal training to develop basic knowledge about clinical practice, the scribing process, and how to interact with patients, providers, and the rest of the care team. Some scribes, but not all, are formally certified by accrediting bodies such as the ACMSS. A majority of them are employed and trained by scribing companies such as ScribeAmerica and ScribeConnect, and then assigned to work with specific HCOs.

While we were not able to identify a "gold-standard" approach for scribe training (eg, a generally agreed-upon competency model),

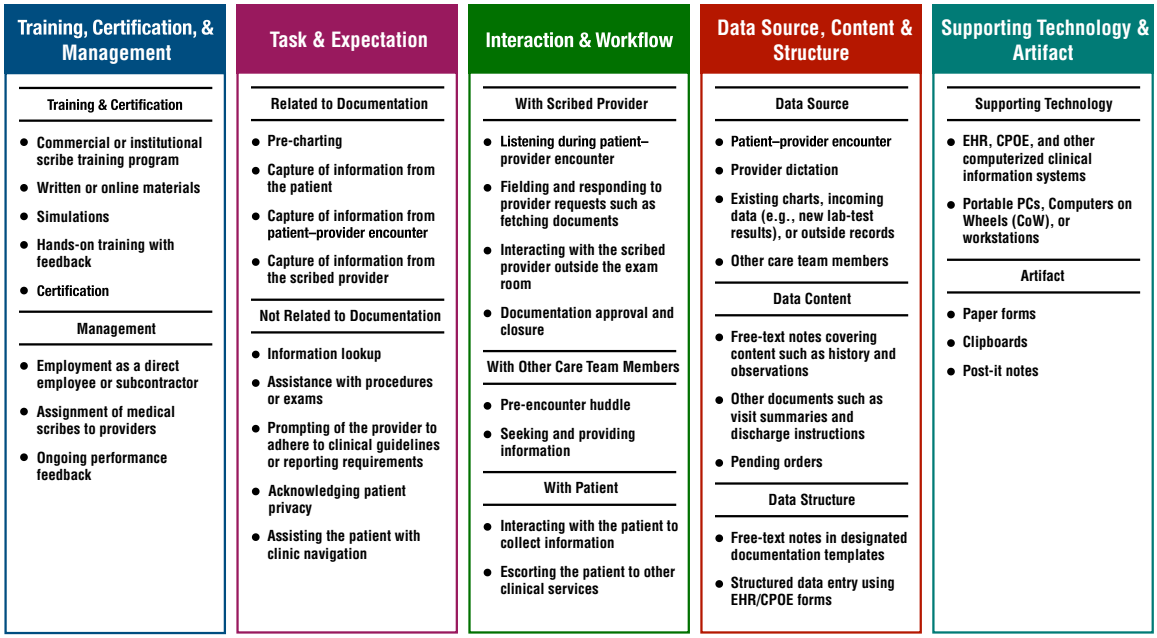

Figure 3. Work Model of Medical Scribes. CoW: computer on wheels; CPOE: computerized physician order entry; EHR: electronic health record; PC: personal computer.

there are some commonalities across different training programs offered by commercial scribing companies[20,24,25,41–52] or by HCOs.[19,22,38,44,45,53–61] Most of the training programs described in the literature are divided into 2 phases: an initial didactic phase and an applied, "hands-on" phase. In the didactic phase, written or online tutorials,[45,53,62,63] quizzes,[56] and clinical simulations[20,25,40,42,44,46,47,54,57,58,62] are used to teach the trainee on clinical procedures, Healthcare Insurance Portability and Accountability Act compliance, medical terminologies, documentation structure, billing and coding processes, and use of clinical information systems such as EHRs. In the applied, "hands-on" phase, the trainee would shadow or practice scribing on real clinical shifts, sometimes with a senior scribe trainer who provides supervision and feedback.[19,46,56,59,60,64] After training, scribes may be subject to continued evaluation and monitoring, such as notes review and regular meetings with a supervisor.[42]

Training of providers

Sometimes, clinicians and clerical staff are also trained on how to effectively work with medical scribes.[40,65] Such training focuses on best practices for integrating scribes into existing clinical workflow, as well as accommodating their presence in the exam room (eg, properly introducing the scribe to the patient), and using "extra verbalization" to signal the scribe that some important information is about to be uttered.[65]

Certification

While certification is not mandatory, several entities in the United States, such as the ACMSS,[66] American Healthcare Documentation Professionals Group,[67,68] and American Academy of Professional Coders,[69] offer voluntary credentialing for medical scribers. The certification process usually involves a written exam to assess the candidate's knowledge, skill, and ability to work effectively in a clinical environment, in addition to an evaluation of the candidate's past scribing experience.

Management

Medical scribes in the United States are commonly managed by commercial scribing companies as subcontractors,[20,24,25,38,41–47,49–52,65,70] even though some are directly employed by HCOs.[19,22,38,44,45,53–61,71] Within an HCO, a scribe is assigned either to an individual provider (the "one-to-one" model)[50] or to a group of providers (the "one-to-many" model),[25] or is available as part of a pooled resource assigned dynamically based on matched schedules (the "many-to-many" model).[49] Use of these management models varies to a great extent depending on the preference of the HCO or of the scribing company.[38,44]

Task and expectation

Medical scribes' main duty is to listen to patient–provider conversations and capture relevant information that needs to be documented.[42,44,48,50,53,54,58,59,65,72,73] Often, after the clinical encounter is completed, they will meet with the provider to add additional information that might not have been discussed while the patient was in the room.[22,24,41–44,47,49,51,56,57,64,65,70,74–82] Scribes will then enter the information into a computerized system either as free-text notes or as structured data.[50,57] In most cases, the information will be subsequently reviewed and approved by the provider, before it becomes part of the patient's permanent medical record.[20,24,25,43,44,48,52–54,57,65,70,72,74,83–85]

In addition, medical scribes are involved in many other activities beyond scribing in the exam room. They are often asked to conduct "pre-charting" (ie, constructing in-progress notes before patient arrival based on historical information, such as summaries of past clinic visits and hospitalizations).[42,44,48,50,53,54,58,59,65,75,78]

During the encounter, medical scribes may also be asked to provide assistance such as looking up information in the EHR (eg, the results of a recent lab test) or tracking progress (eg, on pending orders).[42,45,65,70,77,80] Sometimes, they may be asked to assist the provider in performing certain tasks such as physical exams and clinical procedures.[38,43] Additionally, medical scribes may be asked

to play a housekeeping role to remind the provider to adhere to recommended clinical guidelines or reporting requirements, such as providing counseling on smoking cessation with patients who smoke.[25,76]

A few articles discussed potential privacy concerns that may be associated with medical scribing. In general, these studies found that patients do not perceive the presence of medical scribes in the exam room as a threat to privacy. For example, in an interview study conducted by Yan et al[39] in a primary care setting, patients reported that having clinical scribes in the room did not interfere with their conversation with the provider even on sensitive topics, except for sexual history among male patients. Other survey studies conducted in the emergency department and urology settings share similar findings. In these studies, patient respondents reported that they were conformable with having medial scribes present, which did not cause any difference in their likelihood of disclosing sensitive information.[55,82]

Outside the exam room, a common task that medical scribes are asked to assist with is clinic navigation, such as helping patients complete forms; accompanying them to a laboratory, radiology service area, or exit; scheduling the next appointment; signing up for patient portal; and handing out educational pamphlets or other check-out materials.[38,42,43,58,65,83] They may also be asked to perform certain clerical duties such as delivering or fetching paper forms.[24,38,77] In a study conducted in an Australian emergency department, medical scribes were even asked to locate and call specialists, request medical records from other institutions, and book beds.[45,53,70,85,86]

Interaction and workflow

While performing their job duties, scribes need to constantly interact with patients, providers, and other members of the care team. Their work also needs to be closely integrated with the clinical workflow in order to ensure smooth handling of patients, information, and clinical activities. These interactions and workflow could vary from setting to setting, even from provider to provider. Indeed, Woodcock et al[44] and Schiff and Zucker[87] noted that, in their respective observational studies, some scribes were relegated to playing a completely passive "listener" role, while some others were more actively engaged in the patient care delivery process.'

Interactions with the provider

The most common mode of interaction is no interaction, in which scribes passively listen to the patient–provider conversation while taking notes or entering data directly into a clinical information system. The provider may occasionally use visual cues (eg, gestures, eye contact), or verbal commands, to specifically instruct the scribe to perform an action, such as to document observations of a physical exam or to enter medication orders. At times, scribes will be asked to leave the room (eg, while a sensitive clinical exam is being performed).[46,62] As mentioned previously, the provider may also interact with the scribe outside the exam room to add more information that was not specifically discussed during the encounter.

After the scribe marks their work as completed, the provider would review the chart content, and edit it as they see fit, before "closing" the note.[20,24,25,43,44,48,52–54,57,65,70,74,83–85] Individual providers appear to have different preferences for documentation and consequently different expectations for medical scribes. Several studies reported variations among providers as to what information should be documented, how the initial documentation should be organized, and to what extent the provider would modify scribes' input before committing it in the EHR.[38,44,53,88]

There have also been inconsistent practices as to whether scribes should also include their signature into the note for proper attribution. This process is required by the Joint Commission and American Health Information Management Association guidelines.[80,89] However, the Centers for Medicare and Medicaid Services noted in a 2017 transmittal that scribes were not providers of clinical items or services, and as such, a single signature from the provider would suffice.[90]

Interactions with other care team members

While in the clinic, scribes also frequently interact with other members of the care team such as nurses, physician assistants, medical assistants, and other clerical staff. For example, scribes could be a participant in the pre-encounter huddle that usually involves the entire care team.[48,58,65] Further, as mentioned previously, they may be asked to play a concierge role to help patients navigate in the clinic, through which they become a vital middle person connecting patients with the rest of the care team.

Interactions with patients

Even though scribes are generally not supposed to interact with patients directly, varied descriptions of scribe–patient interactions were reported in the literature. For example, Yan et al,[38] with clinical medical scribes, and Sattler et al,[43] with non–clinically trained scribes, reported that extension of the scribe role toward direct patient interaction was commonplace: scribes frequently built rapport with patients through small talk and were frequently called upon to assist with clinical procedures. Reuben et al[58] also described a program in which non–clinically trained scribes independently interacted with patients to provide after-visit summary and basic patient education. Last, Al-Adwan et al[77] reported that scribes occasionally received and relayed patient requests to the provider.

Data source, content, and structure

Sources of data of scribe-produced draft documentation

Besides capturing information during clinical encounter, scribes also record data from the provider when the patient is not present; for example, in the emergency department setting, scribes often record emergency department course, disposition, and re-evaluation discussions typically taking place outside the exam room.[53,54,59,61,77,81] Often, scribes also draw on data from existing patient charts, such as lab test results, radiology and pathology reports, problem list, current medications, and summaries of past clinic visits and hospitalizations.[42,65,78] Scribes may also utilize data obtained from outside records at the provider's request, such as faxes or paper forms that the patient brought to the clinic.[38,58,65,78]

Content and structure of free-text clinical notes

Many articles that we reviewed contained descriptions of specific structures of a draft clinical note produced by scribes. These include sections such as history of present illness, medical and surgical history, family and social history, allergies, current medications, review of systems, and physical exam, as well as orders and assessment and plan. Use of institution-mandated templates is common,[19,40,42,44,53,57,60,83] as a means to standardize content and structure of clinical documentation. However, it is important to note that such templates vary from institution to institution; within the same institution, they are usually adapted to varied degrees for

Table 1. Design implications for building better digital scribes based on the studies of how human medical scribes conduct their work

1. Because of variation in scribe expectations and responsibilities across contexts, digital scribes need to be adaptable to contextual factors such as institutional needs, regulatory requirements, and individual provider preferences.
2. Scribes' job extends far beyond capturing patient–provider conversation in the exam room. Digital scribing solutions, if solely based on speech recognition and transcript postprocessing, need to be aware of the limited role they are able to fulfill relative to human scribes.
3. When preparing clinical documentation, human scribes need to integrate a considerable amount of information from other sources such as prior charts and lab test results. Therefore, an effective digital scribing solution needs to interface with the EHR and other clinical information systems (eg, laboratory information systems and picture archiving and communication systems) to achieve functional parity with a human scribe.
4. Designers of digital scribing solutions need to be aware of potential patient and provider concerns that may arise due to the fact that their exam room conversations are being continuously recorded. Therefore, such systems need to be mindfully designed to minimize privacy, confidentiality, and liability risks; best practices need to be developed to improve patients and providers' comfort with using such technologies.

each individual provider to fit their different charting styles.[25,38,43,55]

Structured data entry

Besides free-text clinical notes, usually scribes are also allowed to enter structured data directly into the EHR, such as current medications, diagnoses, and procedures.[65,91] They may do it "on the fly" during a clinical encounter, or afterward while completing the rest of the documentation.[24] Scribes can also enter an order (eg, medication, lab test) under a "pending" status, which will be not placed until the provider reviews and approves it.[48,49,58,65] However, this practice varies across HCOs. For example, Pozdnyakova et al[25] and Martel et al[57] specifically stated that, in their respective institutions, only providers, not scribes, could enter orders in the prescriber order entry system (computerized physician order entry [CPOE]).' Yet, a 2018 update on the Joint Commission guidelines on medical scribing deemed pending orders as an acceptable practice because of the fact that they are not immediately actionable without further provider review and approval.[89]

Other content

Some articles noted that medial scribes might also be asked to create some other types of documents related to patient care, such as level of service provided and dictation of materials to be distributed to patients (eg, visit summaries, discharge instructions, school or work notes, educational materials).[24,25,58,59,83]

Supporting technology and artifact

Based on the articles that we reviewed, in most cases, scribes enter data directly into a computerized system (eg, EHR, CPOE),[19,22,25,40,43,44,48,50,57,58,60,64,76,80,92,93] via portable devices such as laptops, computer on wheels,[45,46,57,70] or stationary computer workstations.[44,64] Scribes may also utilize other memory-aiding tools such as paper and clipboards to store information temporarily before transcribing it into a computerized system.[64,76] None of the articles that we reviewed mentioned the use of specific electronic information tools customized for medical scribes to facilitate transitory documentation.

Of note, it appears to be a common practice for the scribe and the provider to have separate user accounts to log into computerized systems such as EHRs and CPOE.[57,80] However, several articles did mention that issues could arise due to simultaneous access to patient charts.[38,43,93] For example, in Sattler et al,[43] the authors observed that the provider was "locked out" from a patient chart while the scribe had it open for transcription.

DISCUSSION

There have been mounting concerns on clinician burnout and its adverse impact on efficiency, quality of care, and patient safety.[94] "Digital scribes," which leverage speech-based technologies to record and automatically transcribe patient–provider conversations into clinical documentation, have been suggested as a potentially viable technological solution, replacing or augmenting the capability of human scribes.[27,95] To inform the development of such technologies, it would be of interest to obtain a better understanding of how human scribes work in real-world clinical settings, including how they interact with patients, providers, and other members of the care team. We believe this review may provide useful insights to fill this gap (Table 1).

First, digital scribes need to be adaptable to contextual factors such as institutional needs, regulatory requirements, and individual provider preferences. In our review, expectations for and work practices of medical scribes are substantially different across HCOs. This finding holds true for all dimensions of our work model, including scribe training, responsibilities, and interactions. Further, individual providers within an HCO may also have different documentation styles and expectations for medical scribing. This means that "digital scribes" will also need to be customizable, to certain degrees, at the individual provider level. This could be further complicated considering additional variations across different medical specialties. Given this variability, successful digital scribing solutions would likely need to be flexible among these dimensions.

Second, digital scribing solutions, if solely based on speech recognition and transcript postprocessing, need to be aware of the limited role that they are able to fulfill relative to human scribes. Based on the review results, scribes appear to be commonly tasked with a diverse set of responsibilities beyond simply serving as silent, passive transcriptionists. For example, medical scribes may interact with the provider (eg, reminding them to collect a specific piece of information from the patient), other members of the care team (eg, communicating the scribed provider's plans with the rest of the care team), and patients (eg, providing after-visit summaries and scheduling follow-up appointments). Many of these activities take place outside the exam room. This finding raises the question as to who should assume these responsibilities when speech-based digital scribing technologies start to be used as a substitute of human scribes.

Third, when preparing clinical documentation, human scribes need to integrate a considerable amount of information from other sources such as prior charts and lab test results. In our findings, patient–provider conversations are not the sole source of information that human medical scribes use in creating clinical documentation. Scribes also rely on sources such as medical histories from prior charts and results of newly completed lab tests. This means that digital scribing technologies that capture only spoken information during the

patient–provider encounter would not be sufficient enough to provide a complete clinical documentation solution. To have functional parity with a human scribe, technology-based digital scribes would also need to interface with the EHR and other clinical information systems in order to incorporate additional streams of data.

Fourth, designers of digital scribing solutions need to be aware of potential patient and provider concerns that may arise due to the fact that their exam room conversations are being continuously recorded. In our reviewed articles, patients are generally comfortable with having medical scribes in the exam room, and they do not believe scribes' presence would interfere with their conversation with the provider even on some sensitive issues. However, it is unclear whether the concerns related to privacy and confidentiality might rise to become a paramount obstacle to the use of speech-based digital scribing technologies. Privacy and liability issues related to providers should also be considered. If unaddressed, these issues may lead to unintended consequences, such as changes on how providers decide what to disclose or not to disclose. All of these issues may be contingent on how such technologies will be designed. For example, whether the digital scribe will use continuous ambient recording that cannot be readily paused by the provider or at the request of the patient; whether the transcription will be performed in real time, thus eliminating the need to store the original audio recordings; and if the recordings ought to be saved, whether they will be destroyed after the transcription is completed or they will be permanently achieved. It is also crucial to develop best practices on how to inform patients about the fact that their conversations with the provider are being digitally recorded, even if the audio files may not be preserved after transcription. Additional research is needed to address these potential concerns in order to improve the acceptance of speech-based digital scribing solutions among both patients and providers.

It is also of interest to note that based on our analysis of publication volume, we found that there was a noticeable surge in the number of studies focusing on medical scribes around 2010 and 2011, and that this pattern only applies to studies conducted in the United States This time frame may coincide with the enactment of the U.S. Health Information Technology for Economic and Clinical Health Act, which has led to the accelerated adoption of EHR systems across U.S. hospitals and clinics since 2009.

This review has several limitations. First, while there have been many studies on medical scribes, most of them focused on outcomes (eg, productivity, cost benefits). Relatively few contained detailed descriptions of medical scribes' training, work practices, and their interactions with patients and the care team. Thus, the results reported in this article, based on review of the extant literature, may not capture all aspects related to medical scribing. Future work is needed to use more empirically based approaches such as observations and interviews to supplement the findings herein presented. Second, over 70% of the articles that met our inclusion criteria were conducted at academic medical centers within the United States. The results may therefore not be generalizable to medical scribes working in other care settings or in international contexts.

CONCLUSION

To address the issue of clinician burnout, there has been a growing interest in developing speech-based technologies capable of transcribing patient–provider conversations to generate clinical documentation automatically. In this study, we sought to conduct a review of the literature to better understand the work performed by medical scribes. The objective was to derive design insights that could inform the development of technology-based solutions that emulate the behavior of human scribes. Based on the findings, we conclude that medical scribes perform complex and delicate work that is much beyond simply transcribing conversations taking place in the exam room. We believe that speech-based technologies provide promising prospects for reducing the burden of clinical documentation. However, to completely substitute the role played by human scribes, a much more comprehensive solution is needed.

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AUTHOR CONTRIBUTIONS

BDT conducted the literature search, analyzed the data, and drafted the manuscript. BDT, YC, and SL conducted the literature screening. KZ contributed to concept development of the study, oversaw the literature search and review, and edited the manuscript.

SUPPLEMENTARY MATERIAL

Supplementary material is available *at Journal of the American Medical Informatics Association online*.

CONFLICT OF INTEREST STATEMENT

The authors have no competing interests to declare.

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