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Eliminating Errors in Vital Signs Documentation

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This study compared two methods of documenting vital signs: a traditional method where staff wrote vital signs on paper then keyed into an electronic medical record and a wireless system that downloaded vital signs directly into an electronic medical record. The study design was pretest and posttest. Sixty-four sets of vital signs were evaluated prior to the implementation of a wireless download system and 66 sets of vital signs were evaluated after. To compare the error rates for the two methods, χ^2 tests were used, and t tests were used to compare the elapsed time. Questionnaires relating to the clinicians' experiences were analyzed qualitatively. The paper vital signs recording had an error rate of 18.75% and the wireless system has an error rate of 0% ($P < .001$). The mean (SD) elapsed time from when the vital signs were taken until they were available in the electronic medical record was 38.53 (32.87) minutes for the paper method and 5.06 (6.59) minutes for the wireless method ($P < .001$). The electronic vital signs documentation system resulted in significantly fewer errors and shorter elapsed time when compared with the paper system.

KEY WORDS

Medical error reduction • Patient safety • Vital sign documentation • Wireless connectivity

BACKGROUND

Documentation of vital signs (VS) is an important nursing function. Although a simple procedure, there are several steps in the process and errors are not uncommon. The frequency of errors has begun to be documented in the literature.[1–4] An assumption is that incorrect VS data may lead to inappropriate medical interventions or a lack of intervention when one was necessary for patient care.

There are multiple methods for transferring VS into a medical record. They can be handwritten on a paper form and then handwritten into a paper record. They can be handwritten on a paper then typed into an electronic medical record (EMR). They can be entered into a mobile device (such as a person digital assistant [PDA]) at the bedside and downloaded into an EMR. They can be typed directly into an EMR at the bedside, or they can be transmitted wirelessly directly from the VS machine into an EMR. Each method of transferring VS has possible risks for error. The errors can be from transcription or transposing numbers when written by hand or typed. There can also be errors of omission, for example, when VS are written on paper and not entered into the medical record or one of the VS measures are not recorded. A failure to transmit the data is also possible (ie, failure of the interface), leading to missing VS.

Several studies were found in the literature that described efforts to improve VS documentation by using different types of data entry devices (for entering VS into an EMR),[5,6] improving the configuration used in the EMR,[7] or in improving nursing processes.[8]

One study reported that nurses spent about 12 minutes per patient per day documenting VS in the ICU when using a paper system and found that after the implementation of a wireless system, the time dropped to 2 minutes per patient per day.[4] In contrast, an ethnographic study found that nurses who worked at a hospital with an EMR spent more time documenting VS than did nurses who worked at hospitals that had paper records. In both types of hospitals,

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Welch Allyn provided the necessary equipment to conduct the study and funding for the independent statistician with a monetary value of $74 000.

The authors have disclosed that they have no significant relationship with, or financial interest in, any commercial companies pertaining to this article.

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DOI: 10.1097/01.NCN.0000432125.61526.27

the nurses recorded VS on paper before rewriting or keying in the VS into the medical record.[9]

Only four studies were found that compared VS error rates before and after implementation of an EMR or wireless transmission of VS data. These studies reported that the frequency of errors in recording VS on paper then transcribing to a paper record was between 10% and 25.6%.[1,2] The error rates for recording on paper then transcribing into an EMR were between 4.4% and 15.2%.[1,3] The error rates for typing in VS at the bedside were 0.08% to 5.6%,[1,3] and the error rate for wireless transmission was 3.3%.[4]

Combining the results of the four studies that compared VS before and after implementation of an EMR was not possible because the studies used different definitions to describe what constitutes an error and used different methods of documenting VS. Table 1 provides the types of transmission methods and their associated error rates for the four studies.

The purposes of this study were to determine (*a*) the difference between the frequency of errors and omissions when VS are documented and transcribed manually into the EMR and when they are recorded automatically into the EMR using Connex Vital Signs Monitors and Connex Vitals Management (VM) implementation and (*b*) the difference between the time it takes to manually document, transcribe, and have access to VS data in an EMR and the time it takes to document and have access to the data using Connex Vital Signs Monitors and Connex VM.

METHODS

When the study hospital needed to purchase new VS machines, the hospital had the opportunity to work with Welch Allyn (a company that makes VS machines with the capability to wirelessly transmit VS to an EMR, based in Skaneateles Falls, NY) to look at VS errors before and after implementation of a wireless VS data transfer system. Prior to the implementation of the wireless system, RNs or licensed nursing assistants (LNAs) documented VS on paper and later typed the VS into the EMR. The baseline error rate was unknown; however, the research team assumed that a wireless transfer of data would decrease overall errors and would allow the VS data to be immediately available in the EMR. This study used Welch Allyn Connex VM software. Connex VM was compatible with the hospital EMR and had the capability to download patient data directly from the point of care via the Connex Vital Signs Monitor. The research team hypothesized that transitioning to wireless connectivity would provide a more timely delivery of accurate patient VS data, which would promote patient safety.

Table 1

Errors in VS Documentation

Author	No. of VS Sets	Type of Transmission	Error rate, %
Smith et al[1]	1514	Paper to paper	10
		Paper to EMR	4.4
		PDA to EMR	0.08
Gearing et al[2]	613	Paper to paper	25.6
	623	Paper to EMR	14.9
Wagner et al[3]	113	Paper at point of care	16.8
	33	Paper to EMR	15.2
	124	EMR at point of care	5.6
Meccariello et al[4]	52	Paper to EMR	13.5
	92	Wireless transmission	3.3

Setting

This study was conducted at a small community hospital. The study was reviewed and approved by the hospital's institutional review board. Patient written consent was waived.

Design

A pretest and posttest design was chosen. An informatics (IS) nurse familiar to the staff observed nurses and LNAs taking VS on a general medical/surgical unit. Phase I of the study was baseline data collection before implementing the new wireless VS system.

During phase I of the study, the staff used older, automatic VS machines that could measure and display heart rate (HR), blood pressure (BP), and oxygen saturation (O_2). Each VS machine also had a separate thermometer. The machines were capable of printing out HR and BP, although in day-to-day practice, this feature was not used by the RNs and LNAs. The printouts did not have the capability of recording patient names, locations, temperature, respiratory rate (RR), or O_2. The nursing staff would routinely write the patient name and VS on a paper form that they carried as they took VS on their patients on the unit. Once the staff finished with their rounds, the VS were keyed into the EMR. During the study, the IS nurse followed the staff, recorded the VS as the staff obtained them, documented the time the VS were taken, and printed the VS from the machines. The VS printouts were used by the research team to compare to the data entered manually into the EMR. The staff was not aware of the true reason for the IS nurse shadowing them during both the pretest and posttest observations. It was not unusual for the IS nurse to shadow staff as different components of the EMR system were introduced or modified. Later, the IS nurse searched the EMR for the VS and documented any discrepancies between the EMR compared

with the printed VS and his observations. The IS nurse also compared the time the VS were taken with the time the VS were available in the EMR via the time stamp on the EMR.

Phase II included the implementation of Connex Vital Signs Monitors and Connex VM using a wireless workflow. After the clinicians were trained on the hardware and software, the same IS nurse observed the staff obtaining and documenting VS. The IS nurse observed the staff taking VS, recorded the VS, and printed the VS as they were being collected. The IS nurse then verified the VS entered into the EMR and documented any errors or omissions. The IS nurse compared the time stamp from when the VS were saved in the Connex Vital Signs Monitor and the time stamp from when the data were available in the EMR.

After phase II of the study was complete, the staff was asked to complete a questionnaire about taking VS.

Sample

A convenience sample of patients on a medical/surgical unit participated in the study. A desired sample size was calculated using the midpoint of previously published data on error rates for recording VS on paper then transcribing to a paper record (10% and 25.6%)[1,2] and comparing this to the published error rate for the wireless transmission (3.3%).[4] It was determined that a sample of 60 VS sets per group had a power estimate of 0.83, which is considered adequate by most researchers who assess the power of their tests using n = 0.80 as a standard for adequacy. A total of 64 VS sets were collected for phase I of the study and 66 for phase II. The VS sets were obtained from patients in a random order using a random assignment table. All patient beds on the medical/surgical unit were listed randomly and the IS nurse observed the VS being taken according to the list. If the bed was empty or if the patient was excluded, the IS nurse would skip that VS observation and proceed to the next bed on the list. When the end of the list was reached, the IS nurse would go back to the top of the list and continue collecting VS information until at least 60 observations were completed. Only patients who needed routine VS obtained were included. Patients who were not able to have routine VS taken were excluded (ie, postoperative patients who needed frequent VS, blood transfusion patients, bilateral mastectomies, or bilateral upper extremity deep vein thromboses). Patients who required frequent VS were excluded from this study because the Connex VM system was designed for intermittent VS and because the IS nurse could not observe the frequent VS and follow the staff person doing routine VS at the same time.

Equipment and Instruments

The Connex Vital Signs Monitor is intended to be used by clinicians and medically qualified personnel for monitoring noninvasive BP, pulse rate, oxygen saturation, and body temperature. The most likely locations for patients to be monitored are general medical and surgical floors, general hospital, and alternate care environments. Connex VM is intended for the collection and review of patient data and the transmission of the data to information systems. It provides notifications when data deviate from preset ranges, allows manual entry of data, and provides a means to identify and manage patients. Connex Vital Signs Monitors and Connex VM are Class II devices and received FDA clearance prior to the start of data collection. Devices that are registered with the FDA are classified into three groups. A Class II device is a "medium risk." Study risks were minimized by using procedures that were consistent with sound research design and were already being performed on the patients.

A data collection form was created that included

- The patient's room number
- The patient's medical record number (used to retrieve the EMR data)
- Date
- The staff identification number (to identify the staff member taking the VS)
- The VS observed and printed
- The VS collection time
- The VS from the EMR
- A space to document any errors
- A space to write in comments
- The IS nurse's signature

To compare the error rates for the two methods, χ^2 tests were used, and t tests were used to compare the elapsed time, that is, the time between the VS being taken and the time the VS were available in the EMR. All analyses were performed using SAS, version 9.2 (SAS, Cary, NC). The research team also devised a follow-up questionnaire to understand the staff's perception of the equipment and process. The follow-up questionnaire included some basic demographic information, such as RN or LNA, and length of time on the unit. Analysis of the open-ended questions on the follow-up questionnaire was conducted using a card-sorting technique. Individual responses to the questions were written on sticky notes. The notes were sorted into categories, each expressing a theme. There were several rounds of sorting until all responses were included into categories/themes.

RESULTS

Fifteen clinicians participated in phase I of the study, and 64 patients were included. For phase II, 13 clinicians participated and 66 patients were included. Data on systolic BP (SBP), diastolic BP (DBP), HR, temperature, oxygen saturation, and RR were collected. Therefore, each

VS set had six measurements that could potentially have errors.

In phase I, the mean (SD) number of errors per VS set was 1.12 (0.98) and ranged from 0 to 4. The overall error rate was 18.75% in phase I. There were no errors in phase II ($P < .001$). Table 2 summarizes the error rate by VS and the method of documentation.

With regard to error rate between phase I and II, HR and O_2 were the most significantly different VS. Both RR and DBP were marginally significant; neither temperature nor SBP was statistically significant.

The mean (SD) elapsed time between collecting the VS and documenting the VS in the EMR for phase I was 38.53 (32.87) minutes and ranged from 3 to 172 minutes. For phase II, the mean (SD) elapsed time was 5.06 (6.59) minutes and ranged from 1 to 32 minutes ($P < .001$).

In addition, for phase I, the VS stamp differed from the time recorded 17 times (a 26.56% error rate). The mean (SD) difference was 15.47 (19.31) minutes. For example, the staff person might have recorded that VS were taken at 8 am but they were actually taken at 8:15 am. In phase II, the data were automatically time stamped when they were stored in the Connex Vital Signs Monitor, so there were no discrepancies.

An analysis of the questionnaire was conducted to understand the staff's perception of the new equipment and process. See Table 3 for demographic information. All 23 respondents collected BP, HR, temperature, and O_2, but only nine collected RR. As shown in Table 4, most of the staff was comfortable using both the old paper to EMR process and the new wireless VS process.

The most commonly listed benefits of the new system were "speed," which was mentioned by 16 (69.6%) people; "accuracy," which was mentioned by eight (34.8%); and "ease of use," which was mentioned by seven (30.4%) people.

Table 2

Comparison of Error Rate Between Phase 1 and Phase 2

	Phase 1		Phase 2		
Vital Sign	Total No. of Errors	Error Rate, %	Total No. of Errors	Error Rate, %	*P*
SBP	3	4.69	0	0	.075
DBP	5	7.81	0	0	.021
HR	39	60.94	0	0	<.001
Temperature	0	0	0	0	.999
O_2	21	32.81	0	0	<.001
RR	4	6.25	0	0	.039
Total	72	18.75	0	0	<.001

All *P* values are from χ^2 tests, and those less than .05 are statistically significant.

Table 3

Demographic Information of Staff Completing the Questionnaire (N = 23)

	%
RN	34.8
LNA	65.2
Years of experience	
<5	34.8
6–10	39.2
>10	26.1

A common concern with the new system was the "inability to enter oxygen data," that is, to document whether the patient was receiving oxygen and how much, which was entered by six (26.1%) participants, and the worry that "data might not send," which was also entered by six people. The staff was concerned that data might not be transmitted. Using the wireless system, VS are not recorded on paper. If the interface fails or if the EMR is down, the VS might be lost. The staff pointed out that new processes need to be followed, such as checking the EMR to be sure the VS were received. Concerns about "wireless" were recorded by two (8.7%) people, and concerns about "forgetting to report the results to the RN" were recorded by two others.

Of note is that the Connex Vital Signs Monitor does have the ability to store VS, so the chance of VS actually being lost is small. Depending upon how long the system is down, perhaps the patient would be discharged and the data never sent. However, the staff did bring this up as a concern for them.

The most common suggestion for improving the new system, which was submitted by nine (39.1%) people, was to include the ability to document whether the patient was on oxygen and, if so, how it was being administered and what the flow rate was. No other suggestion was entered by more than one participant. The Connex Vital Signs Monitor does have the ability to document the method of oxygen administration and the flow rate; however, this feature was not implemented at the time of the study.

Table 4

Comfort With Documentation System

Response	Paper to EMR, n (%)	New Wireless System, n (%)
Very comfortable	13 (56.5)	12 (52.2)
Moderately comfortable	3 (13.0)	6 (26.1)
Comfortable	4 (17.4)	1 (4.4)
Moderately uncomfortable	1 (4.4)	3 (13.0)
Extremely uncomfortable	1 (4.4)	0
Failed to answer	1 (4.4)	1 (4.4)

DISCUSSION

Our results were similar to those of previous studies. The total error rate of 18.75% compares with the 25.6% error rate that Gearing et al[2] found in a paper-to-paper system. The Connex Vital Signs Monitors combined with Connex VM reduced the documentation errors to zero. The average elapsed time from the point when VS were taken until they were recorded in the EMR dropped from 38.53 to 5.06 minutes. Although these data indicate a very successful outcome, there were difficulties in implementing the system.

The study was projected to take approximately 4 months but took more than a year for the IS department of the hospital, Welsh Allyn, and an interface company to be able to transfer the data over the wireless network into the EMR. It required wireless LAN connectivity for Connex Vital Signs Monitors to connect to the Connex VM server located in the hospital's data center and two HL7 messages admission, discharge, transfer [ADT] and results data). An interface was required to convert the information from Welch Allyn into the EMR. Prior to "go-live," an upload of all patient data within the EMR was sent from the EMR's ADT server to Connex VM (Figure 1).

The steps in the process to obtain the VS were as follows. The staff person scanned his/her identification barcode on his/her employee badge and then scanned the patient's ID band before setting up the Connex Vital Signs Monitor. The VS were taken, and once validated, the patient information was sent to the Connex VM by the staff person pushing a button. The Connex VM validated the patient information and created an HL7 interface file, which flowed to the interface server. The interface server received and processed the data and sent the interface files to the Scriplink server. The Scriplink server then posted the data in the EMR.

Alerts were created in the event that data did not come across the interface. For example, if the script stopped, and no VS data were uploaded into the EMR, a page would go out to the IS staff on-call or help desk staff to alert them and a manual reboot of the Scriplink server would be required. Another type of alert was set up for a clinician ID not in the database. Information for new staff members had to be manually entered into the Connex VM. If this was not done, the Connex VM system would not recognize the user and an alert would be sent to the support staff.

This study, and most others in the literature, did not address the risk of harm to patients caused by documentation errors. The error rate in this study and in others is alarmingly high. Most errors are likely to be clinically insignificant. Documenting an HR of 68 instead of 69 is clinically meaningless. However, larger errors are unpredictable, and an SBP of 106 instead of 160 may be very significant for an individual patient. With the high rate of errors, it is also likely that any one patient may have

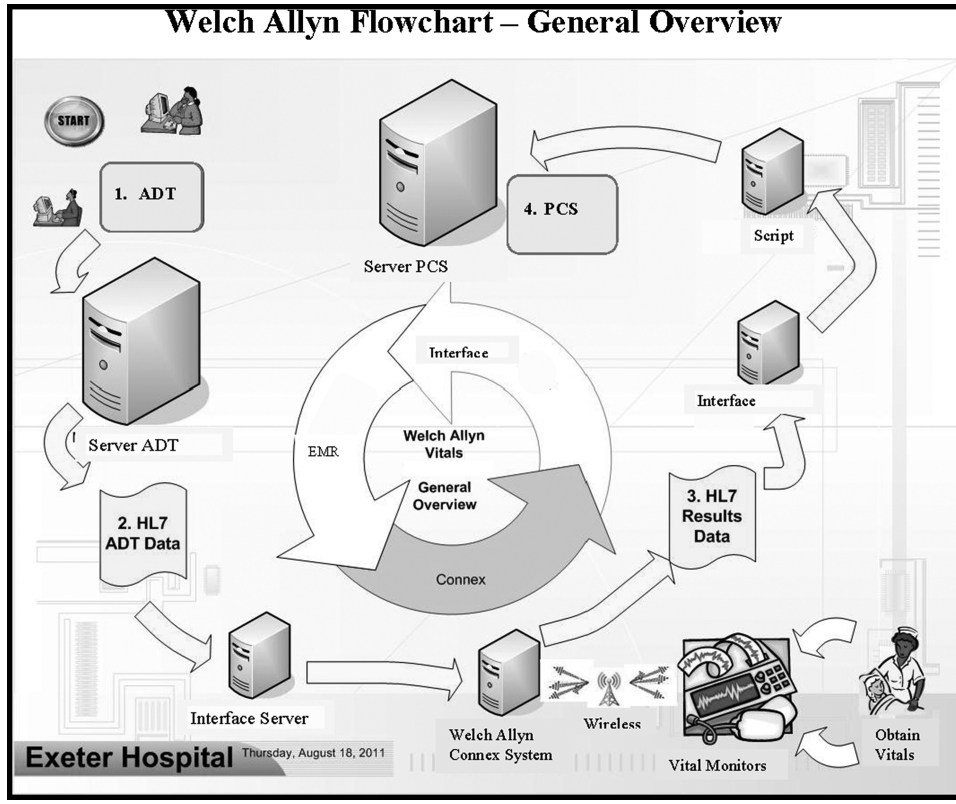

FIGURE 1. Steps in the wireless VS process.

several documentation errors during an inpatient stay. These errors may contribute to clinically significant consequences. While we may not be able to eliminate all VS errors, with improved technology, we can certainly reduce errors significantly.

LIMITATIONS

Limitations of this study include the pretest and posttest design. A parallel arm study would have been more desirable. There was a long delay between phase I and phase II data collection because of the time it took to set up the interfaces properly.

When collecting data on omitted VS, the researchers were able to record only omissions of individual VS within the set of VS. It was beyond the scope of this study to capture entire sets of VS that were missing or not collected. For example, a patient who is ordered to have VS done every 4 hours and is off the floor when the LNA is doing his/her VS rounds may not have the VS done. We did not compare the ordered frequency of VS with the actual recorded VS. Presumably, the LNA or RN would obtain the VS when the patient returned to the unit; however, this was not part of our data collection plan. The actual number of VS errors may be higher than what was reported in both phases if these data had been captured.

CONCLUSIONS

Although implementing the wireless system was more difficult than expected, it eliminated documentation errors and greatly reduced the time for VS to be available in the EMR. The new VS documentation required changes in nursing practice, such as making sure that the documentation assessments had been added to the patient profile before obtaining VS. This is particularly important for new admissions and in-house transfers from departments that do not use this functionality. Other practice changes included scanning employee IDs and patient ID bands and the need to check the EMR to see if the data crossed the interface. A follow-up quality study could be done in the future to ensure that errors continue to be minimized. Further research can also be done on other types of VS documentation systems.

Acknowledgments

We acknowledge the support of the Clinical Research Council at Exeter Hospital. Our statistical consultant was Paul C. Stark, MS, ScD, founder and chief executive officer of Crimson Statistics, Cambridge, MA (paul@crimsonstats.com).

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