

How Vital Are Vital Signs? A Systematic Review of Vital Sign Compliance and Accuracy in Nursing

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ABSTRACT

Increases in patient complexity in healthcare have led to greater efforts to identify early deterioration and adverse events. Key components of these efforts include timely vital sign collection and review as well as Early Warning Systems (EWS). Nurses and nurse assistants play an important role in this area as the primary staff responsible for vital sign collection and documentation, however, some evidence suggests compliance and accuracy in performing this role may be lacking. A systematic review of English language articles published between 2000 and 2014 was performed to assess primary research and literature reviews concerning nursing compliance and accuracy in vital sign collection and documentation as it pertained to adult patients. Results demonstrated a limited number of studies with mixed methodologies, research bias, and varying sample sizes. However evidence was found to support concern regarding nursing compliance and accuracy in vital sign collection and documentation. Based on these findings, recommendations encourage dedicated research to better define nursing compliance and accuracy in vital sign measurements and documentation in both specific and general settings. Likewise, investigation of barriers, causes and reasons for poor compliance and inaccurate results are encouraged. Finally, better research defining the utility and indications for vital sign measurements and EWS in clinical care is needed. Information gained from these efforts can then be applied to nurse education and training, and to the incorporation of new technologies, in an effort to implement effective strategies and solutions to promote better patient care.

Introduction

For a number of decades, healthcare professions and organizations have utilized the recording of vital signs as a means to evaluate the physiological status of an individual. This information, which traditionally has consisted of blood pressure, temperature, pulse rate, respiratory rate and oxygen saturation measurements, is then used to help determine in part a patient's health status (Kyriacos, Jelsma & Jordan, 2011). Recently, with the advancing complexity of patients in both inpatient and outpatient settings, vital signs have garnered increased attention as a means of identifying patients who may be at risk for deterioration and adverse events (Elliott & Coventry, 2012). Quality assurance programs in particular are increasingly stressing prevention and early detection of such potential events (Storm-Versloot, Verweij, Lucas, et al., 2014). Vital

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signs reportedly offer an objective way to determine which individuals should receive immediate attention to avoid or deter adverse events.

Despite widespread use of vital signs for early detection of deteriorating patients and adverse events, debate continues to exist regarding the degree of utility these measurements provide. Of the commonly measured vital signs, respiratory rate continues to provide the best indicator of impending patient deterioration (Philip, Richardson & Cohen, 2013). Storm-Versloot and colleagues (2014) through a systematic review have shown several abnormal vital signs to have high likelihood ratios in relation to increased mortality and Intensive Care Unit (ICU) admissions. However, use of extreme thresholds, methodological flaws of the studies, and marginal significance of results failed to definitively support abnormal vital signs as a useful tool in predicting adverse events (Storm-Versloot, et al., 2014). In addition, the recommended frequency of vital sign collection remains poorly defined in the literature both in general and for specific health conditions (Miltner, Johnson & Deierhoi, 2014). In an effort to enhance the ability of vital signs to serve in this predictive role, the inclusion of additional parameters such as urinary output, pain, and level of consciousness have been recommended by some (Elliott & Coventry, 2012). These considerations have in part led to the development of new scoring systems for predicting patient deterioration.

). In response to a trend of increasing patient complexity, Early Warning Systems (EWS) were developed to package together a number of physiological variables weighted by degree of abnormality into a single predictive score (Storm-Versloot, et al., 2014). This trend has been supported by research at Wake Forest University School of Medicine which reviewed over a million measurements of six different vital signs in 42,430 patients as part of their rapid response team activation protocol. Their results showed one parameter abnormality increased mortality by 0.92 percent while three abnormalities increased mortality by 23.6 percent (Bleyer, Vidya, Russell, et al., 2011). EWS and Modified EWS (MEWS) are now commonly used in both pediatric and adult populations to track patients' conditions and to trigger rapid response teams if needed (Jonsson, Jonsdottir, Moller & Baldursdottir, 2011; Oliver, Powell, Edwards & Mason, 2010). However, these systems have been noted to also have serious limitations,

lack support for a single validated tool, and raise concerns about consistent and accurate implementation (Kyriacos, Jelsma & Jordan, 2011). As a result, the utility of EWS remains somewhat controversial.

In regards to the detection of impending adverse events, and in the collection and recording of both vital signs and EWS/MEWS parameters, nurses play a critical role. Nurse administrators, registered nurses (RN), and nurse assistants each are involved in the accurate collection, recording, and documentation of vital signs in a number of patient settings (James, Butler-Williams, Hunt, & Cox, 2010; Yeung, Lapinsky, Granton, Doran, & Cafazzo, 2012). Failure of nurses, and in particular nurse assistants, to document vital signs correctly not only interferes with quality assessments but similarly undermine EWS as well (Jonsson, et al., 2011). Collins et al (2013) noted that increased nursing documentation and vital sign collection naturally occurs in patients with higher mortality risks. Odell and colleagues (2009) through systematic review found that nurses primarily identify patient risks for deterioration through clinical intuition, pattern recognition, and family alerts more so than through vital sign or EWS assessments. These findings may offer important insights into barriers and obstacles related to the compliance and accuracy of vital sign collection and documentation among nurses.

Some research has reported that nurses fail to comply with the routine collection of vital signs. Oliver et al (2010) reviewed vital sign recordings in 1,000 patients totaling 9,075 recordings over a period of time in all children admitted to their hospital. Blood pressure measurements were collected only 25.1 percent of the time while the highest collection rate was 88.4 percent for temperature recordings. Overall, a full Pediatric EWS (PEWS) set of measurements to detect early deterioration was present in only 52.7 percent of recordings (Oliver, Powell, & Mason, 2010). Other researchers have noted that nurses often fail to obtain respiratory rate measurements (Hogan, 2006; Parkes, 2011). Given the increased attention being awarded to vital signs and EWS in preventing adverse events, determining nursing compliance in vital sign collection is imperative in addition to underlying barriers and causes of poor compliance. This is important for both pediatric and adult patient populations.

In addition to nursing compliance issues related to vital signs, accuracy in collection, recording and documenting vital sign measurements is an additional concern. With advancing technologies, nurses may be relying more heavily on electronic sensors to obtain vital sign measurements rather than adhering to criterion standards (Bianchi, Dugas, Hsieh, et al., 2013). Some researchers have also noted that the use of electronic health records results in the delay of vital sign recording and thus can increase inaccurate documentation (Yeung et al., 2012). And the calculation of EWS scores by nurses has been shown to be prone to error in some case studies (Felton, 2012). Understanding why such inaccuracies exist among nurses in measuring and recording vital signs and EWS parameters is an important part in determining solutions for positive change.

Based on the current issues described related to vital sign collection, EWS, and nursing roles in preventing adverse events, information concerning the frequency of noncompliance in vital sign collection and documentation is felt to be important if these parameters and EWS are going to be used in the future. In addition, the frequency of inaccurate measurements and/or documentation of vital signs among nurses are similarly relevant to this issue. The purpose of this systematic review is to clarify these frequencies, obtain a better understanding of potential causes, and offer recommendations which might improve both vital sign measurement compliance and accuracy among nurses. Regardless of whether vital signs and EWS offer specific advantages in preventing adverse events, these nursing issues directly affect their success in relation to valid and consistent data inputs.

Methodology

In order to examine the frequency of nursing noncompliance and inaccurate recordings of vital signs, a systematic review of the literature was performed. Databases included in the search were CINAHL and PubMed databases with identified research bibliographies also reviewed for relevant literature subject to inclusion and exclusion criteria. Inclusion criteria involved all primary studies or literature reviews which addressed the collection, measurement, recording and documentation of vital signs by nursing staff involving adult patient populations. Both quantitative and qualitative studies were included, and both single vital sign and combination vital sign evaluations

were considered. The articles included also had to be available in English languages regardless of country of origin, had to be available in full text via the databases searched, and had to be published between the years 2000 and 2014. Although all peer-reviewed journals were considered, preference was given to those associated with the nursing profession. Research involving pediatric vital sign collection and recording were excluded as were case studies, expert opinions, and editorials.

Database search terms included the following: vital signs, early warning systems (EWS), modified early warning systems (MEWS), nursing, vital sign collection, nursing compliance, vital sign measurement, vital sign accuracy, inaccurate vital signs, nursing assessment, and patient assessment. Boolean combinations of these terms were performed in searching each database described, and results revealed a total of 1,265 articles. Abstracts of these articles were then reviewed for relevancy, inclusion criteria and exclusion criteria. Of these articles, six were identified as being relevant to the purpose of the review and meeting inclusion and exclusion criteria. Full texts of these six articles were then evaluated in detail.

Results

Of the six studies identified in this systematic review, none demonstrated a thorough assessment of both compliance and accuracy issues related to vital sign measurement, collection and documentation by nurses. Three of the studies examined either compliance or accuracy issues related to the measurement, collection or documentation of respiratory rate only (Ansell, Meyer, & Thompson, 2014; Bianchi, et al., 2013; and Parkes, 2011). The other three studies addressed a more comprehensive assessment of vital sign measurement and recording among nurses (Edmonds, Lomeli, Lovato, & Mower, 2002; Jonsson, et al., 2011; Miltner, Johnson, & Deierhoi, 2014). Of these three more comprehensive studies, only Edmonds and et al (2002) explored vital sign validity and accuracy related to clinical vital sign measurements. See Appendix A for a matrix chart summary of the literature articles included in this review.

In the research performed by Edmonds and colleagues (2002), the reliability of vital sign collections between two clinical staff members were compared in order to determine natural inter-observer variability. Patients were enrolled to

Appendix A
Matrix Summary of Systematic Review Studies

Study	Purpose	Methodology	Results	Notes
Ansell, Meyer & Thompson, 2014	Study to examine rate of collection and documentation of respiratory rate vital signs by nurses and reasons for non-compliance	Qualitative explanatory study performed through semi-structured telephone interviews of 10 registered nurses between 2/2011 and 3/2011	Only 3 of 10 RNs collected and documented RR of patients accurately 100 percent of the time. The remainder omitted RR collection or deviated from protocols due to a variety of reasons which included time pressures, distractions, personal rationalizations, or lack of perceived value.	Study supports both poor VS collection and recording compliance and accuracy among nurses resulting from numerous issues and reasons
Bianchi, et al., 2012	Study to evaluate accuracy of collection of respiratory rates in ED patients by triage nurses	Cross-sectional study with convenience sampling involving 191 patients in an ED with samplings over three different periods comparing usual RR measurement and collection and electronic sensor RR measurements to WHO criterion standards for RR measurement	Compared to criterion RR measurements, usual measurements by ED triage nurses had a sensitivity of 23% and specificity of 99% while electronic sensor measurements had a sensitivity of 91% and specificity of 97% when assessing tachypnea.	Study supports poor accuracy in RR vital sign measurements among ED triage nurses when compared to WHO standards
Edmonds, et al., 2002	Study seeks to examine variability in vital sign measurements between individuals	Inter-observer variability study using two trained clinical staff in measuring heart rate, blood pressure, and respiratory rate in 140 consecutive ED patients between June 1st and August 30th, 1999 with subsequent statistical analysis of variance	Based on statistical result, expected range of agreement (ERA) varied between the two observers by 13.5% for HR, 35.5% for RR, 19.0% for SBP, and 25.7% for DBP.	Study supports a significant degree of inter-observer variability exists between clinical staff in measuring and recording vital signs related to heart rate, respiratory rate and blood pressure
Jonsson, et al., 2011	Study seeks to evaluate accuracy of nursing documentation of vital signs in the Modified Early Warning System (MEWS)	Retrospective, descriptive study performed through medical record review of ED patient charts between 10/1/2006 and 12/30/2006 who were admitted to ICU with total patient charts assessed totaling 65	Results showed most common diagnoses were respiratory failure and septic shock. Findings revealed RR was only documented in 14% of patients; urine output in 40%; level of consciousness in 48%; temperature in 69%; and O2 saturation in 80%.	Study supports findings of poor nursing compliance in vital sign collection and/or recording and challenges related to use of MEWS
Miltner, Johnson, & Deierhoi, 2014	Study examines the frequency with which vital signs are collected and documented by nurses in VA emergency departments	Cross-sectional study performed by collecting and statistically analyzing electronic data in 94 VA emergency departments on 12 separate days in 2011 involving 43,232 patient visits	Findings demonstrated that among ED visits sampled, blood pressure was not obtained in 14.4%; RR in 15.1%; pulse in 14.4%; temperature in 16.8%; and O2 saturation in 33.0%. In addition, 9.1% of VA ED's failed to collect BP less than half the time.	Study supports frequent non-compliance in collection and recording of vital signs in ED's involving several parameters
Parkes, 2011	Study seeks to assess compliance of ED nurses in collecting and recording RR in relation to the total and to specific complaints	Retrospective, cross-sectional, random sampling study consisting of an audit of 594 adult patient ED records presenting over a 3 day period in May 2010	Chart review was performed identifying RR documentation and patients' presenting complaints. Overall, RR was documented in only 29% of charts. However RR was present in 91% of patients with shortness of breath, 63% of those with chest pain, and 31% of those with abdominal pain.	Study shows significant non-compliance in recording RR vitals in ED patients with variance related in part to presenting symptoms.

participate in this study based on consecutive presentation to the emergency department (ED) in a busy urban medical center between June 1st, 1999 and August 30th, 1999. Vital sign measurements performed included heart rate, respiratory rate and blood pressure measurements, and all total, 140 patients/measurements were included for statistical analysis (Edmonds, et al., 2002). Results between the two observers demonstrated significant Expected Range of Agreement (ERA) ranges among all vital signs recorded. ERA for heart rate measurements varied by as much as 13.5 percent while ERAs for respiratory rate, systolic blood pressure, and diastolic blood pressure were 35.5 percent, 19.0 percent, and 25.7 percent respectively (Edmonds, et al., 2002). Given these results, the authors concluded significant inter-observer variability exists between clinical staff in measuring vital signs, and thus reliability as well as accuracy is questionable both between observers as well as between different samplings (Edmonds, et al., 2002).

Miltner et al (2014) assessed compliance in collecting and recording vital sign assessments by reviewing de-identified electronic patient data obtained from numerous Veterans Administration (VA) emergency rooms. Data was collected concerning blood pressure, pulse, respiratory rate, temperature and oxygen saturation over twelve randomly selected days in 2011, and these measurements were correlated with time stamps, lengths of stay, emergency service severities, and dispositions (Miltner, Johnson, & Deierhoi, 2014). Relevant to this systematic review, descriptive statistical results showed oxygen saturation was not recorded by ED nursing staff in 33 percent of patients, and omissions in blood pressure, pulse, respiratory rate, and temperature recordings were present in 14.5 percent, 14.4 percent, 15.1 percent, and 16.8 percent respectively. Results also noted that in 9.1 percent of VA emergency rooms, fewer than half the patients received blood pressure measurements (Miltner, Johnson, & Deierhoi, 2014). Based on this large-scale study, noncompliance in measuring, collecting, and documenting vital signs is prevalent among ED nursing staff.

Jonsson and colleagues (2011) also examined compliance among nurses in collecting vital signs as defined by MEWS parameters in their institution in patients being emergently admitted to an ICU setting. In a retrospective, descriptive

study examining medical charts of emergently admitted patients to the ICU from the ED between October 1st, 2006 and December 30th, 2006, a total of 65 patient charts were assessed. Among these charts, respiratory rates were documented in only 14 percent of the patients; temperature in 69 percent; oxygen saturation in 80 percent; urinary output in 40 percent, and level of consciousness in 48 percent (Jonsson, et al., 2011). Given these figures supporting significant noncompliance in vital sign parameter collection and documentation, the authors concluded insufficient data existing for MEWS to be effective (Jonsson, et al., 2011). This study again supports and alludes to a widespread problem related to poor vital sign collection and documentation among nurses.

According to the National Institute of Health and Clinical Excellence (NICE), respiratory rate represents the most important vital sign in predicting patient deterioration and adverse events (Parkes, 2011). Parkes (2011) therefore targeted this vital sign in assessing nursing compliance in measuring and recorded respiratory rate among adult ED patients during a three-day period in May, 2010. In an audit involving 594 adult ED charts, reviews were performed in an anonymous and randomly selected fashion. The presence of a documented respiratory rate was evaluated both in total and in relation to specific patient presenting complaints (Parkes, 2011). Results of this audit demonstrated that overall, nurses documented respiratory rate in only 29 percent of the charts. However, this figure varied with presenting complaints as 91 percent of those with shortness of breath had a documented respiratory rate, yet only 31 percent of those with abdominal pain had similar documentation (Parkes, 2011). In addition to supporting vital sign noncompliance as being common, this study also hints to the fact nursing clinical discretion may play a part in noncompliance behaviors.

Ansell et al (2014) also addressed compliance among nurses in collecting and documenting respiratory rates; however, their study was a qualitative explanatory study seeking to identify not only occurrences of noncompliance but also efforts toward achieving accurate measurements and reasons behind poor practices. Semi-structured telephone interviews of 10 registered nurses conducted between February and March in 2011 found that only 3 of those interviewed admitted to collecting respiratory rate in an accurate fashion 100 percent

of the time. The remaining 7 nurses either did not collect respiratory rate in some instances, or they took shortcuts in collection protocols or provided estimations of respiratory rates (Ansell, Meyer, & Thompson, 2014). Numerous reasons were cited as to why noncompliance and inaccuracy trends occurred with time pressures, distractions, devaluations of the parameter, and other rationalizations for its unimportance being most common (Ansell, Meyer & Thompson, 2014). Though limited in its scope and sample, this study does support significant compliance and accuracy issues in relation to nurse vital sign collection practices.

Respiratory rate measurement accuracy was similarly addressed by Bianchi et al (2012). In a cross-sectional study utilizing convenience sampling, 191 patients presenting to the ED received three separate respiratory rate measurements. The first measurement was performed by ED nurses through usual routines of care; the second set was then obtained via electronic sensor machines; and the third set obtained by criterion standards established by the World Health Organization (WHO) which require a full 60 seconds of observation for accurate recording of respiratory rate. The latter was used as the gold standard by which the other two measurements were analyzed (Bianchi, et al., 2012). Results demonstrated that in patients with tachypnea, usual care approaches had a sensitivity of only 23 percent despite a specificity of 99 percent. In contrast, electronic sensors had a sensitivity of 91 percent and a specificity of 97 percent (Bianchi, et al., 2012). This study again highlights concerns over respiratory rate measurement accuracies among nurses specifically and vital sign measurement accuracies in general.

Discussion

In performing this systematic review, a relatively few number of studies fell within the criteria and scope of this exercise. However, despite these limited studies, evidence supporting the presence of noncompliance and inaccurate vital sign collections, measurements and recordings exist based on this review. Given the data and results assessed, numerous issues are present involving nursing vital sign practices including issues related to measurement accuracy, inter-observer variability, adherence to protocols, collection inconsistencies among patient types, and overt omissions in collections. The findings of this review therefore support a vital need for

ongoing investigations and research into these areas.

In four of the studies, nursing compliance in collecting and documenting vital signs in total or in part was shown to be poor to a significant degree (Ansell, Meyer, Thompson, 2014; Jonsson, et al., 2011; Miltner, Johnson, & Deierhoi, 2014; and Parkes, 2011). Despite each of these studies highlighting a high degree of patients/charts with poor vital sign documentation, or a high percentage of nurses not performing vital sign tasks, the range among these rates of noncompliance varied significantly. In part, this reflects the multiple methodologies used, the various sites of investigation, different means of statistical analysis and assessment, and in some, the limited number of cases assessed. While these variations amongst the data make it difficult to state with any degree of certainty the frequency of nursing noncompliance related to vital sign measurements and collections, the studies still support its common presence within the scope of nursing. This finding is noteworthy as it pertains to the profession and to the use of vital signs and related systems in predicting patients who may deteriorate or suffer from impending adverse events.

Even fewer of the studies examined accuracy of vital sign measurements among nurses and clinical staff (Ansell, Meyer, & Thompson, 2014; Bianchi, et al., 2012; Edmonds, et al., 2002). Most telling was the qualitative study by Ansell and colleagues (2014) which noted nurses admitting to purposeful alterations to respiratory rate protocols due to extraneous factors. Though this study was limited to a few nurses, the number admitting to taking shortcuts in vital sign measurements, and the reasons provided for these decision, indicates a more systemic problem in nursing in general (Ansell, Meyer, & Thompson, 2014). In addition to these findings, Edmonds et al (2002) noted a natural presence of inter-observer variability in vital sign collection among clinicians. Both of these findings in these studies may account for the findings by Bianchi and colleagues who noted a very low sensitivity among nurses in detecting tachypnea in ED patients when compared to WHO criterion standards of respiratory rate management. Taken together, these studies suggest accuracy in vital sign measurement and reporting may be due to noncompliance in following protocols and due to inherent variability problems as well.

While the reviewed studies focus on nursing compliance and accuracy in collecting vital signs, ongoing debates concerning the utility of vital signs and of EWS in identifying early deterioration or adverse events remains poorly studied as well. Storm-Versloot and colleagues noted that a dichotomy exists in the literature concerning the timing of vital sign changes in relation to adverse events. Older studies cite vital sign changes occur within a few hours of such an event while newer studies suggest vital sign changes either do not show significant changes or fail to occur in a timely fashion to facilitate interventions (Storm-Versloot, et al., 2014). Similarly, Kyriacos and his colleagues (2011) have also noted the limitations of EWS with no single EWS scoring tool being validated in the literature across different diagnoses. Thus how vital signs are best utilized in preventing adverse events still remains unknown.

Regardless of the ambiguity of vital sign and EWS utility in identifying early deterioration, both measures require valid data inputs in order to offer any degree of effectiveness if some utility is eventually proven. Vital sign parameters as a result must be consistently performed among all patients, and the methods of measurement, collection and documentation must be uniform enough to permit reliability and validity. Nurses and nurse assistants, as the primary staff responsible for these measurements, play a critical role in this process of identifying early deterioration and adverse events through vital sign collection and recording. Given the data available in this review, although limited, concerns about nursing performance in performing this vital role should be recognized.

Though the intent of this systematic review was not necessarily to identify reasons, causes and barriers to good compliance and accuracy among nurses in vital sign collections, some of the research did allude to important issues in this regard. Some of the most common issues were related to insufficient time resources, distractions from multi-tasking, and individual judgments about the importance of vital signs (Ansell, Meyer, & Thompson, 2014). Other researchers have also cited poor decision-making skills, equipment management issues, and poor nurse activity organization as important issues in this area also (Hogan, 2006). Indeed, studies demonstrate that vital signs are not a primary means by which nurses determine

early deterioration among patients. Instead, clinical intuition and experience play a more significant role (Odell, Victor, & Oliver, 2009). If objective data involving vital signs and EWS are to be utilized in this fashion, it would appear greater efforts to educate and train nurses in vital sign collection and recording skills, and to instill a greater sense of value and dedication in this area, are needed.

As a final comment, technological advances have resulted in changes in many areas of healthcare. Technology has similarly affected vital sign collection, recording and documentation as well. While some studies report improvements in vital sign accuracy through the use of technologies, others have demonstrated how vital sign documentation may result as well (Bianchi, et al., 2012; Yeung, et al., 2012). Parkes (2011) commented also that in many instances nurses are relying too heavily on machines to collect vital signs rather than ensuring vital sign measurements are accurate and well documented. In addition to correcting actual compliance and validity issues among nurses in performing vital sign measurements and recording them appropriately, identifying how to best utilize technologies in this area will also be important in future pursuits.

Recommendations

The most important recommendation regarding the issue of nursing compliance and accuracy in vital sign measurement and documentation would be to better quantify and define the actual rates of noncompliance and inaccuracies among nurses in clinical practice. The systematic review failed to reveal a large amount of research articles for review; moreover, among those identified, varying methodologies, mixed sample types, research bias, and in some cases, small sample sizes limited the reliability and validity of the evidence. Regardless, enough support is noted to encourage large-scale studies in this area to better define nursing noncompliance and invalid vital sign recordings in both specific and general settings.

In addition to these efforts, studies to expand on the existing literature in defining barriers, obstacles and reasons for poor compliance and accuracy among nurses in vital sign collection should be conducted. At the same time, greater efforts to educate, train and evaluate nurses in proper vital sign measurement techniques efficient should be a priority.

Accurate documentation protocols, improved decision-making skills, and awareness of vital sign values to patient care should be primary areas of focus.

Lastly, ongoing research needs to better quantify and define the utility of vital signs and EWS in adult patients in both specific and general settings. This research should include better definitions of the frequency required for such measurements in relation to optimal patient outcomes. With this knowledge, nurses can be better educated about the usefulness of vital sign measurements and simultaneously appreciate their value in achieving healthcare outcomes. This knowledge can in essence serve as a source for cognitive behavioral change to improve compliance and accuracy issues in vital sign collections.

Authors

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