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Differences in the Rothman Index Score in Evolving Emergent Events in Medical-Surgical
Patients

Presented to the Faculty of the School of Nursing
The George Washington University
In partial fulfillment of the
requirements for the degree of
Doctor of Nursing Practice

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Abstract

Background: The Rothman Index (RI), an early warning system using software integrated with the electronic medical record provides scores monitoring patient conditions. Minimal findings exist regarding RI scores in medical-surgical patients.

Objectives: Explore differences in the RI scores in medical-surgical patients who suffered rapid response, cardiopulmonary resuscitation or death events.

Methods: A retrospective comparative design of 75 subjects with a rapid response or cardiopulmonary resuscitation event on medical-surgical units over 12-months at an academic medical center using RI scores at admission, 48- and 24-hours before and at time of event. Deaths were identified immediately following the emergent events.

Results: The RI scores were significantly higher on admission compared to RI scores at time of rapid response or cardiopulmonary resuscitation event ($p<0.001$). The RI scores at 48 hours prior to event were significantly higher compared to the scores at event time ($p<0.001$). RI scores at 24 hours before the event were significantly higher compared to the RI scores at event time ($p<0.001$). No differences were found between the RI change scores in patients who died and those who remained alive ($p=0.83$).

Conclusions: Differences existed in RI scores from admission, 48 and 24 hours prior to the time of emergent events. Earlier identification of patient condition changes through the nursing process, combined with an integrated early warning system in the electronic medical record, may reduce emergent events in medical-surgical patients. A collaborative dialogue between nursing and medical staff is crucial to timely recognize and treat conditions to minimize opportunities for emergent events.

Background

Subtle changes in patient conditions oftentimes are not identified in a timely manner by nurses and providers in an acute care hospital setting. The changes, if unnoticed, may progress to a rapid response or cardiopulmonary resuscitation event or even death. Braaten (2015) completed a qualitative descriptive study on cognitive work analysis describing factors shaping medical-surgical nurses rapid response team (RRT) activation within a hospital system. System themes that prevented providers in identifying subtle or gradual patient changes included inadequate staff resource availability, lack of information on which to base decisions, lack of multiple strategies to manage changes, justification of activation of a RRT and informal social rules affecting when a RRT is activated (Braaten, 2015, p. 25).

Over the years, early warning systems have been developed in an attempt to predict patient outcomes and recognize signs of deterioration more rapidly. One such system, the Rothman Index (RI), works in conjunction with the electronic medical record (EMR) and predictive analytics to provide a score based on various data points to identify signs and symptoms of patient deterioration. The RI uses 26 clinical metrics including vital signs, laboratory results and functional status based on nursing assessments. Vital signs include heart rate, respiratory rate, systolic and diastolic blood pressures, temperature and oxygen saturation. Lab results include sodium, potassium, creatinine, chloride, hemoglobin, blood urea nitrogen and white blood cell count, if available. Functional nursing assessments are comprised of the Braden scale (pressure ulcer risk), cardiac, heart rhythm, peripheral vascular, respiratory, gastrointestinal, food/nutrition, genitourinary, musculoskeletal, safety/fall risk, psychosocial and neurological including Glasgow Coma Scale and level of consciousness (Perahealth, 2016, p.5). The scores are calculated for all patients located on medical-surgical and critical care units

regardless of diagnoses or condition. The scores populate in a colored graph format (blue, yellow and red) with all scores viewable simultaneously at a central monitoring station on each nursing unit and individually on each EMR workstation. The blue graph is indicative of patients with the lowest risk of deterioration with scores ranging from 65 to 100. The yellow graph has scores ranging from 40 to 65, which is an area where clinicians should closely monitor the patients (Banoff, Milner, Rimar, Greer & Canavan, 2016). Rothman, Rothman & Beals (as cited in Henderson, McCloskey, Walter, Rimar, Bai and Moritz, 2017, pp. 232-233) noted a RI score of 40 or less indicates a patient is at high risk for deterioration in the hospital. Rothman, Levy, Dellinger... & Beals, (2017) noted the RI scale ranges from 100 to -91 where a score of 100 is indicative of an unimpaired patient and a negative score is indicative of a patient in an intensive care setting (p. 238). Rothman, Levy, et al (2017) stated most patients admitted to a hospital have a RI score of 85 where those with a RI score of 65 are discharged to skilled nursing facilities, patients with a RI score of 40 may be considered for transfer to the ICU and a score of zero is typically the lowest score seen on a medical-surgical unit (p. 238). The 26 clinical measurements are continuously collected and updated in real time throughout the patient stay, resulting in tracking of the “evolving patient status” throughout their stay (Rothman, Tepas, et al, 2017, p. 181). Nursing assessments comprise 34%, vital signs comprise 35% and lab results comprise 31% of the RI computation (Rothman, Rothman & Beals, 2013, p. 843). Rothman, Tepas, Nowalk, Levin, Rimar, Marchetti & Hsiao (2017) noted the adult RI and pediatric Rothman Index (pRI) are focused on displaying the physiologic impact of disease and treatment rather than the cause of the patient condition. The RI has been validated and correlates with measures associated with the patient condition (Rothman, Rothman & Beals, 2013). The RI score applies the most data points for calculation as compared to other early warning systems.

Problem Statement

Since establishing use of the RI at our institution, minimal data have been collected regarding identification of those medical-surgical patients who have suffered rapid response or cardiopulmonary resuscitation events. As a result, exploration of the relationship between the RI score and identification of these events is essential. Nursing assessment documentation is a critical component of the RI. Through utilization of the RI, nurses can identify changes, both subtle and obvious, in the RI score and escalate care to the patient before a rapid response or cardiopulmonary resuscitation situation occurs.

Purpose

The purpose of our study was to assess whether there were differences in the RI score upon admission compared to the RI score at the time of the rapid response or cardiopulmonary resuscitation event as well as 48 and 24 hours before the event in patients on a medical-surgical floor. An association between the change in RI score (from admission to event) and patient death was also examined. Differences in the RI score upon admission compared to the RI score surrounding the evolving emergent event indicate the need for escalation of care and treatment to prevent progression to a rapid response or cardiopulmonary resuscitation.

Specific Aims

The specific aims of our study included:

- 1) Measure the number of rapid response events and cardiopulmonary resuscitation events on medical surgical units, which may or may not include telemetry monitoring, over a one year period.
- 2) Identify RI scores on admission and compare to RI scores on the date of event, 48 hours before the event and 24 hours before the event.

- 3) Determine the percentage difference in the RI score from admission to the date of event.
- 4) Identify if there is an association between the change in RI score (from admission to event) and death.

Hypothesis

The following research hypotheses were tested:

1. There are differences between the admission RI scores and the RI scores at the time of the rapid response or cardiopulmonary resuscitation event.
2. There are differences between the RI scores 48 and 24 hours before the event and the RI scores at the time of the rapid response or cardiopulmonary resuscitation event.
3. Among patients who had a rapid response or cardiopulmonary resuscitation event, there is an association between the RI change scores (from admission to event) and death.

Significance

A patient's condition in the hospital setting can change in an instant. Subtle changes may be present and go unnoticed. Patient condition is not well defined and encompasses numerous variables. If a patient condition deteriorates, timely escalation of care is required.

The nursing process is a key component incorporated into the registered nurses interaction with their patients. Assessment, diagnosis, outcomes/planning, implementation and evaluation are performed during each shift, for every patient (American Nurses Association, 2017). Detailing information identified during the nursing process allows an interdisciplinary team to coordinate care for the patient. Even with best efforts to record information in the EMR, occasionally, subtle patient changes can be missed, which may lead to eventual failure to rescue circumstances, transfer to a higher level of care or even death.

Health information technology, through use of the EMR, has evolved to facilitate sharing patient information, monitoring trends over time, improved documentation and improving quality of care. Utilization of real time EMR patient data to identify patient outcomes is an area where science and technology meet. Preventing delays in care escalation will allow for better patient outcomes. Additional research must be completed to show the relationship between science and technology. Our facility is fortunate to have the opportunity to utilize the RI as an early warning system to more quickly identify even subtle changes in patient status. Earlier identification of changes will enable nurses and providers to timely treat patients, thus preventing emergent situations where a rapid response or cardiopulmonary resuscitation event occurs. Patient safety and do no harm are priorities. Leveraging the use of technology can help with patient safety efforts and minimizing risk and harm to patients.

Literature Review

An initial literature search was conducted using PubMed and Scopus databases and identified 57 articles, with four meeting inclusion and exclusion criteria. An updated literature search was conducted using PubMed and Scopus in October 2017, identifying 20 articles with two meeting inclusion and exclusion criteria. Additional information was initially reviewed and subsequently updated from the Perahealth website where Perahealth Publishing Activities for Peer Reviewed Articles, Oral Presentations and Posters was available. Many of the pertinent articles relating to the RI identified in the database literature search were also included in the Perahealth information. Relevant articles reflected information on the Modified Early Warning Score (MEWS) with comparison to the RI, validation of the RI and supporting evidence for using the RI to identify when a patient may require escalation of care to prevent a rapid response or cardiopulmonary arrest event.

Rothman, Rothman and Beals (2013) developed and validated a continuous measure of general patient condition not predicated based on diagnosis or hospital location, such as medical-surgical or critical care units. The RI was developed using 26 clinical measurements and the methodology estimated in-hospital risk associated with each of the measures. The methodology was then validated against outcomes from three hospitals in the United States and reviewed 170,000 medical-surgical and critical care patients (Rothman, et al, 2013). Outcome validation across hospitals revealed an area under the receiver operating characteristic curve (AUC) of ≥ 0.92 with the patient discharge category, an AUC of ≥ 0.93 with prediction of 24 hour mortality and AUC of 0.62 with prediction of 30 day readmission (Rothman, et al., 2013, p. 841). The model was based on a longitudinal view of a patient's condition and incorporated earlier identification of patient acuity, communication amongst care providers and continuity of care (Rothman, et al., 2013). The RI has been validated in three outcome categories. Use of the validated RI methodology allows for additional research in varied settings such as an academic medical facility.

Validity of nursing assessments with clinical implications such as in-hospital mortality and post discharge mortality was the focus of a study at an 805 bed community hospital. Nursing assessment data for January 2004 to December 2004 and July 2005 to June 2006 were obtained from the EMR. Patient population included all patients admitted for any reason during the specified time periods excluding obstetrics, pediatric and psychiatric patients. Mortality data was acquired from the Social Security Administration. The binary charting by exception model was used where the assessment "met" or "not met" the standard for 12 areas which included food, neurological, safety, skin, genitourinary, musculoskeletal, respiratory, cardiac, peripheral vascular, gastrointestinal, psychosocial and pain (Rothman, Solinger, Rothman & Finlay, 2012).

In all nursing assessment categories for in-house and post-discharge deaths, significantly higher death rates and high mortality odds ratios (ORs) with the exception of the pain assessment occurred where assessment standards were not met. All results, except pain assessments, were statistically significant ($p < 0.001$) and none of the 95% confidence intervals overlapped (Rothman, Solinger, Rothman & Finlay, 2012, p. 3). Rothman, Solinger, Rothman and Finlay (2012) calculated an intraclass correlation coefficient comparing all ORs for 2004 and 2005-2006, for all categories and time points. The time points used contained in-hospital and 2, 30 and 365 days post-discharge. The intraclass correlation coefficient was 0.85 (Rothman, Solinger, Rothman & Finlay, 2012, p. 3). The conclusion of the authors were nursing assessments, except for pain, correlated strongly with in-hospital and post-discharge mortality regardless of diagnosis or medical history. The nursing assessments were shown to be sensitive indicators of patient condition and may aid in identifying clinical problems throughout the in-hospital stay. Rothman, Solinger, Rothman and Finlay (2012) stated nursing assessment data was noted to be essentially unused, however, use of this data would permit physicians to improve care. This study validates the significance of nursing assessments as a clinical data source in monitoring patient condition.

Rothman, Rothman and Solinger (2013) completed a modelling study in an 805 bed community hospital to explore the hypothesis that placing clinical variables on a linear scale of all-cause post discharge mortality produced risk functions that were directly correlated with in-hospital mortality. The population consisted of all inpatients admitted for any reason, excluding obstetrics, pediatrics and psychiatric patients. Mortality data was acquired from the Social Security Administration. This was a successive study completed to demonstrate and validate development of an index obtained from data in the EMR. This study computed risk functions for vital signs and laboratory blood tests, showed relevance of one year post-discharge risk functions

to risk in the hospital by computing the correlation between in-hospital risk and post discharge risk and showing the sum of the risk functions correlated with patient acuity at the time of discharge as indicated by the patient's discharge disposition (i.e. to home, skilled nursing facility, etc.) (Rothman, Rothman & Solinger, 2013, p. 2). Two excess risk functions were calculated for every variable, along with the Pearson correlation between them which were established from post discharge mortality related to the last value before discharge and in-hospital mortality related to the first values after admission. An overall risk score was determined by adding the 12 nursing assessment categories, heart rate and creatinine level documented in the EMR to determine the risk score. The risk scores were tested to determine if there was a relationship among conditions of discharged patients with categories comprised of home, home with healthcare, rehabilitation center, skilled nursing facility, hospice and death. An analysis of variance (ANOVA) and Tukey's Honestly Significant Difference Test were performed to determine the separation of means (Rothman, Rothman & Solinger, 2013). When comparing the in-hospital risks with post discharge risks for the 12 nursing assessment categories, heart rate and creatinine, the Pearson correlation coefficients were 0.892, 0.922 and 0.920. A correlation with the MEWS heart rate element was 0.855 (Rothman, Rothman & Solinger, 2013, p. 1). With risk score summation, first-approximation patient risk score was generated which correctly ranked six discharge categories by average mortality with $p < 0.001$ for differences in the category means while Tukey's Honestly Significant Difference Test validated all means were different at the 95% confidence level (Rothman, Rothman & Solinger, 2013, p. 1). A method was demonstrated to assess inpatient risk based on information in the EMR. The study provided the foundation toward creation of a universal measure of patient condition and examining patient assessments. This study was pertinent to our study since it supported

quantitative assessment of the acuity of an inpatient regardless of diagnosis or co-morbid conditions.

Comparison of the accuracy of the MEWS and the RI in predicting hospital death within 24 hours was completed at a 665 bed regional referral center and teaching hospital in Pennsylvania. The population for the retrospective review included patients 18 years of age and older for the period July 2009 to June 2010. Input variables from the EMR for each group were compared using a t test with a Cochran and Cox approximation of the probability level of the approximate t statistic for unequal variances (Finley, Rothman and Smith, 2014). In comparison with the MEWS, the RI showed superior discrimination of 24 hour mortality with $p = < 0.0001$ (Finley, et al., 2014, p. 118). The MEWS score elicited a typical trigger alarm at a value of 4 while the RI value for a typical trigger alarm was 16. The RI point corresponding to equal sensitivity was identified. The positive likelihood ratio (LR+) for MEWS was 7.8 and 16.9 for the RI where false alarms were reduced by 53% (Finley, et al., 2014, p. 118-119). The RI point of 30 was noted to capture 54% more of patients who would die within 24 hours (Finley, et al., 2014, o. 119). This study was relevant to our study since the RI was shown to be statistically significant in predicting patient outcome for 24 hour mortality.

Sankey, McAvay, Siner, Barsky and Chaudry (2016) evaluated the impact of delays in escalation of care among clinically deteriorating patients in the inpatient setting of an urban, tertiary academic medical center. The retrospective study analyzed data from 2011 to 2013 with review of 793 patient records. The authors defined “deterioration to door time” as the time between documented onset of clinical deterioration (in the EMR) and the patient’s arrival to the Medical Intensive Care Unit (MICU) (Sankey, et al, 2016, p. 896). Clinical deterioration was defined by vital sign abnormalities including respiratory rate, systolic blood pressure and heart

rate. The RI was used to identify severity of illness where a RI score of less than or equal to 30 indicated a severe illness. The study found systolic hypotension, tachypnea and tachycardia were the common measures associated with clinical deterioration. One-third of the sample were categorized as severely ill based on the RI score. Mortality rates in the study were 19.8% compared to 8% of patients without vital sign clinical deterioration prior to transfer to MICU (Sankey, et al., 2016, p. 897). Mortality ranged from 75 to 84% based on discharge diagnosis, however, there was no statistical significance. A significant increase in mortality was identified beginning at a deterioration to door time of 12.1 hours after age, gender and severity of illness were adjusted. No statistical significance for mortality was identified for deterioration to door times of 0 to 2.5 hours and 4.6 to 12 hours. Patients with higher acuity declined with an increase in time to transfer and the relationship between severity of illness and deterioration to door time was statistically significant with $p=0.006$ (Sankey, et al., p. 898). The findings were consistent with previous studies where delays are common after the onset of clinical deterioration and delays in transfer to an intensive care unit (ICU) were associated with increased mortality (Sankey, et al., 2016). This study was relevant to our study since it supported the relationship between deterioration, escalation of care and mortality.

A study evaluating vital sign data and the RI score to predict critical interventions for pediatric patients was completed at an academic children's hospital. A retrospective review of 220 EMRs between January 2006 and July 2011 examined hospitalized children with a mean age of 6.7 ± 6.7 years who experienced a cardiopulmonary arrest or who required an urgent intervention with transfer to the ICU. Study subjects encompassed those with 24 hours of EMR data. The physiologic parameters reviewed were comprised of temperature, heart rate, systolic and diastolic blood pressure, respiratory rate and peripheral oxygen saturation. The RI was

implemented at the facility in April 2009. The RI was reviewed for the period April 2009 to July 2011. Sensitivity and specificity for a model consisting of any two vital sign measures and the pediatric RI of 40 or lower to predict both conditions in the 24 hour period before the event was used. The authors concluded vital sign only models had a higher sensitivity than the pediatric RI but were associated with a high false-positive rate (Da Silva, Hamilton, Horvat, Fink, Palmer, Nowalk, Winger and Clark, 2015). This study did not use the RI in clinical decision making or activation of an emergency response team. This study was relevant since the high specificity of the RI score may serve as an electronic prompt, in addition to human interpretation of clinical data, to identify the need to escalate care before a rapid response or cardiopulmonary arrest event occurs.

A retrospective correlation of the initial RI, average inpatient RI and lowest RI scores to incidence of complications and/or post-operative sepsis was studied at a teaching hospital for the period June 2011 to October 2011. The purpose of the study was to assess the correlation of the RI as an indicator of physiologic status to preoperative morbidity and postoperative complications (Tepas, Rimar, Hsiao & Nussbaum, 2013). Tepas, et al., (2013) studied 74 laparoscopic patients and 54 open colon resections with 64 patients (51%) with documented perioperative complications. Ten patients (8% of the population) had severe sepsis with 40% mortality (Tepas, et al, 2013, p. 921). A total of 261 complications were identified, illustrating 82 different diagnoses. The initial RI defined the physiologic starting point of the inpatient care. The average RI encompassed patient status throughout the hospital stay and the lowest RI score evaluated the relationship of pathophysiologic base to outcome. The color coded RI graphs (blue, yellow and red) defined the groups. Each group was stratified by the number of complications defined by discharge International Classification of Diseases, 9th revision, Clinical

Modification codes with sepsis evaluated individually (Tepas, et al., 2013). Independent variables included age and color coded risk level and dependent variables consisted of number of complications, cost and duration of stay. A one way ANOVA compared age, complications, costs and duration of stay for all groups. Tukey-Kramer multiple comparisons assessed the differences between groups with alpha set at .05 (Tepas, et al., 2013). There were no differences in color coded risk level and age however, there was a correlation with risk with number of complications, direct cost and duration of inpatient stays where all varied significantly for all three RI measures (Tepas et al, 2013, p. 921). A pairwise comparison of the three color coded risk groups demonstrated varying levels of significance with the red graph category being statistically significant for all three measures (Tepas et al, 2013, p. 921). This study was relevant since statistical significance was identified between the red, yellow and blue RI score graph areas showing a relationship existed between various areas regarding average number of complications and average length of stay.

A retrospective case controlled study of 248 adult inpatients was performed at Yale New Haven Hospital between February 2013 and September 2014 to determine if use of the RI, would be effective at predicting a patient's risk of deterioration. According to the authors Malkhasyan, Brian, Rimar, Andreozzi, Hannah-Shmouni and Donohue (2016) known early warning systems have shown low efficiency in predicting deterioration of a patient's condition. A group of 124 subjects experienced an in-hospital cardiopulmonary arrest. A control group of 124 subjects did not experience an in-hospital cardiopulmonary arrest but were matched by date, time, level of care and principal diagnosis during the identified time frame. RI scores on admission and 48 hours prior to the in-hospital cardiopulmonary arrest were compared using a mixed linear model statistic and change point analysis. Baseline characteristics including age, gender and first

documented RI did not differ significantly by group. The final regression model ($p=0.022$), adjusted for first RI and principal diagnosis, showed significantly lower scores in the in-hospital cardiopulmonary arrest group beginning at 46 hours and 8 hours before in-hospital cardiopulmonary arrest for ICU and non-ICU patients respectively (Malkhasyan, et al, 2016, 11). Change point analysis in the in-hospital cardiopulmonary arrest group revealed a significant breaking point in RI scores' declining trend at 2 and 3 hours before in-hospital cardiopulmonary arrest in non-ICU and ICU patients respectively (Malkhasyan, et al, 2016, 11). The study is relevant since statistical significance was identified with RI score changes over time, along with a significant breaking point over time with declining RI scores in both ICU and non-ICU settings resulting in in-hospital cardiopulmonary arrests which suggests the RI is useful for clinical management.

Wengerter, Pei, Asuzu and Davis (2017) reviewed 217 post-operative rapid response team (RRT) activation cases during the period 2013 to 2015 which were matched to four control cases from the same hospital floor with at least three RI readings within the same 24 hour time period at a large tertiary care facility in the northeast United States to determine how fluctuation of the RI over 24 hours could predict RRT activation. Patients with a history of previous RRT activation during the same admission were excluded. The change in RI as a predictor of RRT was assessed with RI variability quantified as RI standard deviation and maximum-minus-minimum RI over a 24 hour period. RI standard deviation and maximum-minus-minimum RI were related to RRT activation after gender and age were adjusted ($P < 0.05$) (Wengerter, et al, 2017, p. 3). RRT and RI standard deviation or maximum-minus-minimum RI was quantified using area under the curve. RI standard deviation predicted RRT with area under the curve of 0.74, 95% CI (0.70, 0.77). Maximum-minus-minimum RI predicted RRT with area under the

curve 0.76, 95% CI (0.72, 0.79). No significance difference in area under the curve between RI standard deviation and maximum-minus-minimum RI ($p = 0.428$) was noted (Wengerter, et al, 2017, p. 3). Specificity and sensitivity for prediction of RRT with a cutoff of 3.0 for RI standard deviation and cutoff of 8 for maximum-minus-minimum RI to maximize sensitivity was performed. At the cutoffs, RI standard deviation predicted RRT with sensitivity of 91.7% and specificity of 39.9%. Maximum-minus-minimum RI predicted RRT with a sensitivity of 92.2% and specificity of 39.9%. RI standard deviation identified 5 of 17 (29%) of patients missed by maximum-minus-minimum RI and maximum-minus-minimum RI captured 4 of 16 (25%) of patients missed by RI standard deviation. The RRT cases in the study had higher in-hospital mortality rates compared to controls (adjusted odds ratio 17.4, $P = 0.008$). Wengerter, et al (2017) utilized the maximum-minus-minimum RI to predict in-hospital mortality, however, maximum-minus-minimum RI and RI standard deviation were not significant predictors (adjusted odds ratios of 1.06, $P = 0.36$, $P = 0.21$) (p. 3). This study is relevant since an increased likelihood of RRT activation was predicted with use of the RI.

Based on literature reviewed, documentation was present to validate a relationship between the RI and escalation of care. Gaps in knowledge exist when identifying an evolving emergent event.

Theoretical Framework

The theoretical foundation utilized for this study was the Normalization Process Theory (NPT). The NPT was developed between 2000 and 2009. May, Mair, Finch, MacFarlane, Dowrick, Treweek...Montori (2009) acknowledged it provided a set of sociological tools to understand and explain social processes where new or modified practices of thinking, enacting and organizing work are operationalized in healthcare and other settings. There are three central

components which include implementation, embedding and integration. Implementation entails the social organization enacting the practice or practices. Embedding describes the process where the practices do or do not become consistently incorporated into the daily workflow for groups and individuals. Last, integration signifies reproduction and sustainability of the processes among members of the organization or institution (May, et al., 2009). Gould, Hale, Waters & Allen (2016) acknowledged NPT is a sociological theory identifying factors promoting or prohibiting incorporation or normalization of interventions to every day practice (p. 376). It was also classified as an action theory since it involves embedding change by both individuals and teams.

There are four mechanisms of the NPT which include coherence, cognitive participation, collective action and reflexive monitoring (May, et al., 2009). Coherence can be interpreted as determining if staff have an understanding of the reason the new practice or system has been implemented. Cognitive participation entails determining if staff are engaged and committed to the practice or system and identifying components that support or prohibit the commitment. Collective action establishes if members of the organization are using the practice or system and identifying those factors which support or prohibit use of the practice or system. Last, reflexive monitoring examines if staff have evaluated the practice or system and impact on practice (Scantlebury, Sheard, Watt, Cairns, Wright & Adamson, 2017). Holtrop, Potworowski, Fitzpatrick, Kowalk and Green (2016) noted an intervention is considered successful if it becomes part of normal practice.

The NPT was chosen for this study since it related to both individuals and groups integrating an intervention, in this case the RI, embedding it into practice and evaluating if there has been an impact on practice. The RI was instituted initially as a pilot on a medical-surgical,

intermediate care unit and intensive care unit for one month and was subsequently initiated to all other inpatient nursing units. An impact on practice was recognized as a result of the study. If the implementation, embedding and integration of the RI are in place, a proactive approach by both nursing and medical staff will be taken when subtle changes are noted in the RI score.

Identifying and Defining Study Variables

The independent variables were time of the admission, time of the rapid response or cardiopulmonary event, time 48 hours before the event and time 24 hours before the event. The time signified the actual time the first RI score was recorded after the patient arrived to the medical-surgical nursing unit. The time of the event indicated the actual time the rapid response or cardiopulmonary resuscitation event was identified. For the 48 hour period before the event, the time period encompassed the period between 44 and 52 hours. The 24 hour period before the event encompassed the period between 20 and 28 hours.

Numerous dependent variables were reviewed. The dependent interval variables encompassed the RI score at time of admission, at time of event, 48 hours and 24 hours before the event based on the actual RI score recorded in the EMR. Death, a dependent variable, was defined as absence of brain, cardiac and respiratory function and present or absent.

Clinical variables were reviewed and included the inpatient, medical-surgical location where the patient had either a medical or surgical diagnosis. Presence or absence of telemetry monitoring, previous rapid response event during the hospitalization and previous cardiopulmonary resuscitation event during the hospitalization were other clinical variables studied. A clinical/nominal variable on patient unit location history was reviewed to determine if the patient had a history of being on the medical-surgical unit only during the hospital stay or if there was a transfer from a higher level of care (progressive care, intermediate care or intensive

care) within two (2) days, three (3) to five (5) days or more than six (6) days prior to the rapid response or cardiopulmonary resuscitation event.

Demographic characteristics of the study subjects were reviewed. Information on age, gender, race and marital status was examined (see Table 1). Other demographic information included if the patient was transferred to a higher level of care, died or remained on the medical-surgical unit.

Methods

Research Design

A retrospective comparative research design was used in this study. This design was chosen since it was an appropriate approach to answer the proposed hypotheses. The data collection was longitudinal since the data were collected over time which allowed for a comparison to determine if differences existed amongst the data. This design was also realistic and feasible. The principal investigator was able to complete the study in the defined period of time.

Study Sample

A convenience sampling technique was utilized. Patients included in the study were ages 18 and older, male or female, and all racial and ethnic backgrounds who had a rapid response or cardiopulmonary resuscitation event while present on a medical-surgical unit, with or without telemetry monitoring and admitted with medical or surgical diagnoses. Patients excluded from the study were those located in the emergency department, postpartum, labor and delivery, operating room, post-anesthesia care, progressive care, intermediate care and intensive care units. Patient meeting the inclusion criteria were evaluated from May 1, 2016 through April 30, 2017.

Sample Size

We performed power analysis to determine the number of subjects to be studied. With power of 0.8 (or 80%), alpha of 0.05, assuming the within subject correlation to be 0.7, we needed 75 cases to identify a difference with moderate effect size ($d=0.5$) (<http://www.sample-size.net/sample-size-study-paired-t-test>).

Setting

Data were collected at a large academic medical center in central Pennsylvania consisting of 548 licensed beds with 462 adult hospital and 86 children's hospital beds. The medical-surgical units, with or without telemetry monitoring, consisted of 245 of the total 462 adult hospital beds. The sample included patients located on one of the eight medical-surgical units. Over a one year period of time, approximately 250 rapid response calls were activated throughout the facility and over 50 cardiopulmonary resuscitation events were called on medical-surgical units. The length of time to obtain the sample took two weeks from receipt of the pertinent reports with the identified study population.

Instrumentation and Measurement

A data collection tool was developed by the principal investigator to extract all data from the EMR. The medical record number was used to link the RI scores, demographic clinical, nominal and categorical variables for each subject. Once all data were extracted, the medical record number was deleted from the database prior to data analysis. Each subject was assigned an identifier.

Various MIDAS reports were requested to identify the sample. The first report, entitled Nurse Crisis Log Report, included entries of the Nurse Resource Coordinators following rapid response and cardiopulmonary resuscitation events. The second MIDAS report requested

included patients who suffered Cardiopulmonary Arrest Outside of ICU Setting and Complications Post-Surgery/Procedure – Cardiopulmonary Arrest.

A Business Objects report entitled Resuscitation Record was included of all medical records containing the MR 35 Resuscitation Record for the identified period. The last report was an Eclipsys report which focused on service code charges identified in the EMR based on usage of crash cart drawers three, four and five. Crash cart usage may have been related to a rapid response or a cardiopulmonary resuscitation event.

Once all reports were generated and received, the EMR for patients meeting study inclusion and exclusion criteria were reviewed. All subjects' medical record numbers and date of event meeting the inclusion and exclusion criteria were cross referenced to all reports received in order to prohibit duplicate entries. All data collected were extracted solely from the EMR.

Data Collection Procedure

Our study was approved as expedited by our medical center's Institutional Review Board (IRB) as well as the George Washington University (GWU) IRB. The principal investigator requested a modification to add a column on the data collection tool for number of days between admission and date of event, which was approved.

The principal investigator, a registered nurse with a Master's of Science in Nursing (MSN) degree and enrolled in a Doctor of Nursing Practice (DNP) program at GWU collected all data once duplicate patients were eliminated. All variables identified were abstracted into the Research Electronic Data Capture (REDCap) database which is our institution's database. Initially 68 subjects met the inclusion criteria. A reassessment of the EMR reports was subsequently performed and an additional seven (7) subjects were found to meet the criteria, making the total number of subjects 75. No additional subjects were enrolled.

The principal investigator provided training to the data auditor regarding location of pertinent RI information in the EMR. The data audit for the review was performed using REDCap. The REDCap report sorted the subjects by date rapid response or cardiopulmonary resuscitation events occurred. The data audit, performed to determine the accuracy of data entry, started randomly with the third subject listed and every sixth (6th) subject was subsequently chosen. A total of 13 subjects were audited, resulting in a 17 percent review. Findings included data discrepancies for four subjects. Three subject admission times with corresponding RI scores conflicted with the data collected. One subject's time of event was entered incorrectly. The principal investigator then reviewed the remaining 58 records to determine if all data entered was correct. Of those reviewed, five (5) admission dates were not correct, resulting in incorrect corresponding RI scores. Three (3) discrepancies were identified and subsequently changed regarding number of days between admission and date of event. Three admission times, along with corresponding RI scores were also identified. One entry was not coded as the medical record number (MRN) but rather the OOS account for the patient. The appropriate MRN was then entered. All discrepancies identified were corrected by the principal investigator.

Data Analysis

Data were collected by the principal investigator and entered and stored on the secure REDCap database. Confidentiality of data was maintained. All data were coded with a study ID code linking to the list maintained in the REDCap database in order to prevent any subject identification. The data set, without the study identification code or medical record number identification, was downloaded to SPSS 23 for statistical analysis.

Descriptive statistics were performed to identify sample characteristics. This information was reported in a table format with frequency and percentage noted for each variable.

The level of statistical significance for all hypothesis testing was set at .05. The first hypothesis determined differences between the admission RI score and the RI score at the time of the rapid response or cardiopulmonary resuscitation event. A paired t-test was performed.

The second hypothesis determined the differences between the RI scores at 24 and 48 hours before the event and the RI score at the time of the rapid response or cardiopulmonary resuscitation event. A paired t-test was performed.

The third hypothesis explored the differences between the change of RI score (from admission to event) and death among patients who had a rapid response or cardiopulmonary resuscitation event. An independent t-test was performed to measure the change score as a continuous variable.

Ethical Considerations

Maintaining confidentiality and privacy of human research subjects is of the utmost priority. In order to protect privacy of the human subjects, information collected was limited to minimum necessary to complete the study. Besides the principal investigator, the data reviewer was the only other person with access to the identifiable data during the review for data accuracy. Identifiers included names, medical record number, elements of dates and study code number with linking list and any other unique identifying number, characteristic or code. Following all data collection and a check for accuracy of data entry, all medical record numbers and dates were deleted from the database before analysis.

Results

Demographic and Clinical Characteristics of the Sample by Event Type

The sample size consisted of 75 patients with 29 (39%) in the rapid response group and 46 (61%) in the cardiopulmonary resuscitation group (Table 2). For the total group, 77% (n=58)

of the patients were aged 55 and older (Table 2). Males comprised 56% (n=42) of the total sample with 54.8% (n=23) experiencing a rapid response and 45.2% (n=19) experiencing a cardiopulmonary resuscitation event (Table 2). Females comprised 44% (n=33) of the total with 69.7% (n=23) experiencing a rapid response and 30.3% (n=10) experiencing a cardiopulmonary resuscitation event (Table 2). Of the total group, 86.7% (n=65) were white and 50.7% (n=38) were married (Table 2). At the time of the rapid response and cardiopulmonary resuscitation events, 21.3% (n=16) were subsequently transferred to the intermediate care unit, 54.7% (n= 41) were transferred to the intensive care unit and 24% (n=18) remained on the medical-surgical unit (data not shown). Subjects admitted with medical diagnoses included 70.7% (n=53) of the sample with 66% (n=35) in the rapid response group and 34% (n=18) in the cardiopulmonary resuscitation group. Subjects admitted with a surgical diagnosis included 29.3% (n=22) of the subjects with 50% (n=11) in the rapid response group and 50% (n=11) in the cardiopulmonary resuscitation group (Table 2). Five subjects (6.7%) had telemetry monitoring in place at the time of the event (Table 2). No subjects suffered a previous rapid response or cardiopulmonary resuscitation event (data not shown). No significant differences were found between patients with a rapid response and cardiopulmonary resuscitation event by age, gender, race, marital status, transfer to a higher level of care, admission diagnosis or telemetry monitoring.

Hypotheses Testing Results

Hypothesis 1 was tested for differences between the admission RI score and the RI score at the time of the rapid response or cardiopulmonary resuscitation event. The RI scores on admission (57.97 ± 18.27) were significantly higher than the RI scores at the time of the rapid response or cardiopulmonary resuscitation event (47.04 ± 19) in 75 subjects ($t=4.54$, $p < 0.001$; Table 3).

Hypothesis 2 was tested for differences between the RI scores at 48 hours and 24 hours before the event and the RI score at the time of the rapid response or cardiopulmonary resuscitation event. The RI scores at 48 hours before the event (53.98 ± 16.45) were significantly higher than the RI scores at the time of the rapid response or cardiopulmonary resuscitation event (44.17 ± 19.72) in 49 subjects studied who remained hospitalized for at least 48 hours ($t=3.95$, $p < 0.001$; Table 3). The RI scores at 24 hours before the rapid response or cardiopulmonary resuscitation event (52.62 ± 16.11) were significantly higher than the scores at the time of the event (43.89 ± 19.10) in 59 subjects who remained hospitalized for at least 24 hours ($t=4.60$, $p < 0.001$; Table 3).

Hypotheses 3 was tested to determine whether there was an association between the change of RI score (from admission to event) and death in patients who had a rapid response or cardiopulmonary resuscitation event. For the total group, there were 7 deaths (9.3%). Significantly more patients died in the cardiopulmonary resuscitation group ($n=6$, 85.7%) versus the rapid response group ($n=1$, 14.3%; $p= 0.01$).

The RI change score was calculated from admission to event. No significant difference was found between the RI change scores between those who died (9.34 ± 16.23) and those who remained alive (11.09 ± 21.33) among patients who had a rapid response or cardiopulmonary resuscitation event. Because of the small number of deaths, the effect size was calculated revealing a difference of 0.09. This difference was inconsequential and supports the non-significance finding (Table 4).

Discussion

Identifying subtle and obvious changes in a patient's condition can be challenging for nurses and providers. The RI has been found to be a technological tool utilizing nursing

assessments, vital signs and select laboratory results already recorded in the EMR to identify the patient's risk for deterioration in the inpatient setting. Defining clinical deterioration is challenging. Sankey et al (2016) evaluated the impact of delays in escalation of care among clinically deteriorating patients in an urban academic medical center where delays in care after clinical deterioration and delays in transfer to the ICU were associated with increased mortality. In our study, mortality immediately following the rapid response or cardiopulmonary resuscitation event was 9.3% of the sample. Our study findings support the need for timely identification of deterioration through assessment and a reduction of RI scores with prompt escalation of care in order to prevent an emergent event from occurring, which in turn may decrease mortality.

One objective of this study included determining if differences existed between the RI scores at the time of event and 48 and 24 hours prior to the event in medical-surgical patients. Malkhasyan et al (2016) studied subjects who experienced in-hospital cardiopulmonary arrests. The regression model was adjusted for the first RI and principal diagnosis and demonstrated significantly lower scores in the in-hospital cardiopulmonary arrest group beginning at 46 and 8 hours before the event in both ICU and non-ICU patients ($p=0.022$)(p. 11). Our study demonstrated significant differences ($p<0.001$) were present at both 48 and 24 hours prior to the rapid response or cardiopulmonary resuscitation event. The findings by Malkhasyan et al and in our study are noteworthy since both demonstrate significant reductions in the RI scores in medical-surgical patients up to 48 hours before the rapid response or cardiopulmonary resuscitation event.

Wengerter et al (2017) evaluated and determined RI variability in surgical patients was likely to predict a rapid response team (RRT) activation (p. 41). Maximum minus minimum RI

and the RI standard deviation were shown to be predictors of RRT activation in surgical patients, but not in prediction of in-hospital mortalities. Wengerter et al (2017) noted changes in the RI could be used as an indication of clinical deterioration and impending RRT (p. 41). Our study supports the hypothesis there are differences between the RI scores on admission and at the time of rapid response or cardiopulmonary resuscitation event, along with supporting the hypothesis there are differences in the RI scores at 48 and 24 hours prior to the rapid response or cardiopulmonary resuscitation event. Like Wengerter et al, our study also supports changes in the RI scores could be valuable in identifying clinical deteriorations in medical-surgical patients. Wengerter et al were able to predict RRTs, however, they were not able to predict in-hospital mortalities. Wengerter et al, findings support our final hypothesis where there was no statistical significance or differences between the change of RI scores and death among patients who suffered a rapid response or cardiopulmonary resuscitation event.

Limitations

Our study had several limitations. First, documentation of rapid response events in the EMR is not consistent throughout the academic medical center in contrast to cardiopulmonary resuscitation events, which are documented consistently. Numerous reports were required in order to identify the rapid response sample. Additional reports may have provided supplementary information and more sample subjects. Second, not all patients remained on the medical-surgical unit for at least 48 hours before experiencing a rapid response or cardiopulmonary resuscitation event. Those who did not remain on the medical-surgical unit for at least 48 hours may have required a higher level of care for an admission location instead of admission to a medical-surgical unit. Third, the time period chosen for the study encompassed the initial period when the RI was rolled out to the facility. Training documentation for nurses

and providers was not reviewed to determine number and percentage of existing or new clinical staff trained during the study period.

Implications/Recommendations

Our study findings, along with a suggested action plan, will be disseminated at the academic medical center to improve practice of both nurses and other providers. Dissemination of the findings will be provided by the principal investigator to key stakeholders including the Chief Quality Officer, the Chief Nursing Officer, the Vice President of Operations, the Nurse Resource Coordinator team, the Adult Resuscitation Committee and the Patient Safety Committee. The academic medical center is an accredited Magnet facility, therefore, findings will be discussed at the Nursing Professional Practice Council and Nursing Research and Evidenced Based Practice Council. The action plan for improving use of the RI includes re-education, development of standard workflow related to the RI, policy development related to emergency response activation and escalation of care and continuous quality improvement activities related to patient outcomes following rapid response and cardiopulmonary resuscitation events.

Our findings support the need for re-education of existing nursing and provider clinical staff, as well as education for newly hired clinical staff. An education plan was in place prior to the initial RI rollout, however use of the RI was accelerated to all inpatient areas prior to completion of the plan. As a result, both existing and new staff may not have received initial training or may have only received limited training on the RI. From a provider perspective, interns, residents, fellows and attending physicians may have limited exposure to the RI during the on-boarding process. Stakeholders must be made aware a level setting education program must be developed and implemented for current nursing, interns, residents, fellows and provider

staff. An education plan for newly hired clinical staff must also be developed and implemented for each new employee as part of the orientation and on-boarding process.

We will recommend to stakeholders that policies and/or protocols relating to emergency response activation and escalation of care should be developed and revised to incorporate use of the RI in identifying changes in patient condition in a timely manner through nursing assessments, science and technology. Policy language or protocol development for escalation of care could include notification of providers with identification of a specific percentage change or numerical drop in the RI score. Incorporation of the RI scores and trends must be a standard component of hand off communication for nursing at shift changes, when rounding with providers, in discussion with Nurse Resource Coordinators rounding on the unit and when changes in patient condition are identified. Development of a standard workflow for escalation of care may prevent rapid response, cardiopulmonary resuscitation or death events.

Quality improvement activities related to patient outcomes following a rapid response and cardiopulmonary resuscitation event should continue to be closely monitored on a monthly basis, including unplanned transfers and return transfers to the intensive care unit to determine if the RI, in conjunction with the nursing assessment, were instrumental in identifying an evolving emergent event. Results of the findings must be disseminated to stakeholders with action plans in place to resolve issues identified to improve patient outcomes. Interdisciplinary teams should work together to resolve issues.

The Nurse Resource Coordinators standardized workflow must continue to include review of the RI scores for all patients house wide during hand off communication at shift change, while rounding on the units, when called to evaluate patients and when responding to

rapid response or cardiopulmonary resuscitation events and throughout the shift. Nurse Resource Coordinators are essential in escalating care to providers when called to a nursing unit.

We will also recommend to stakeholders that bedside nurses be empowered to embrace the RI as part of daily care. Staff nurses must incorporate examination of the RI scores and trends as part of their ongoing patient assessment throughout their shift, during handoff communication at shift change and when rounding with providers. While charge nurses and Nurse Resource Coordinators may also monitor the RI scores and trends, the bedside staff nurse is responsible for the total care of the patient and must take ownership of the care. The nurses must be prepared to escalate care to providers when a change in RI score is identified in order to prevent a rapid response or cardiopulmonary resuscitation event or death.

Further research is necessary to address identifying timely changes in patient condition in medical-surgical patients. Patient outcomes such as death and unplanned or return transfers to the intensive care unit following rapid response or cardiopulmonary resuscitation events should continue to be monitored. Additional studies on the triage admission process and placement to medical-surgical units is also needed.

Conclusions

Our study documented that significant differences existed in RI scores from admission to time of event and for the periods 48 or 24 hours before the event and time of event. In those cases where the patient died following a rapid response or cardiopulmonary resuscitation event, no association was identified between the RI score change from admission to event and death. Management of a patient's care is complicated and multifaceted. Early identification of changes in patient condition through nursing assessments, in conjunction with an early warning system integrated in the EMR, simultaneously could reduce the number of emergent events in medical-

surgical patients. In a continuous effort to reduce patient harm, prompt identification of changes in patient condition will minimize the likelihood of a patient transfer to a higher level of care or even death. A collaborative dialogue continues to be crucial between nursing and medical staff in order to immediately recognize and treat patient conditions to minimize the opportunities for rapid response and cardiopulmonary resuscitation events.

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Table 1. Identification and Description of Variables

Variable Name	Variable Type and Form	Theoretical/ Descriptive Definition	Operational Definition/Specification
Type of Event	Independent	Rapid response is an emergent call for the hospital team to respond due to patient deterioration. Cardiopulmonary resuscitation is the absence of heart rate or respirations for which a Code Blue is called.	1 = Rapid response event occurred 2 = Cardiopulmonary resuscitation event occurred
Time of Event	Independent	Point in time when event occurred	Actual time of the rapid response or cardiopulmonary resuscitation event
RI Score at time of event	Dependent/Interval	Score at point in time of hospitalization	Actual score at time of event as recorded in the electronic medical record
Admission Time	Independent	Point in time admitted to the hospital	Actual time nursing assessment completed after patient arrived to the nursing unit when first RI score recorded.
RI Score upon admission	Dependent/Interval	Admission RI score on admission	First RI score recorded on admission in the electronic medical record.
Time 24 hours Before Event	Independent	Point in time 24 hours prior to event. Encompasses the time period between 20 and 28 hours before the event	Actual time nursing assessment completed when RI score recorded 24 hours before the event.
RI Score 24 hours before the event	Dependent/Interval	24 score at point in time of hospitalization.	Actual score 24 hours before event as recorded

Variable Name	Variable Type and Form	Theoretical/ Descriptive Definition	Operational Definition/Specification
			in the electronic medical record.
Time 48 hours Before Event	Independent	Point in time 48 hours prior to event. Encompasses the time period between 44 and 52 hours before the event	Actual time nursing assessment completed when RI score recorded 48 hours before the event.
RI Score 48 hours before event	Dependent/Interval	48 hours score at point in time of hospitalization	Actual score 48 hours before event as recorded in the electronic medical record
Death	Dependent/Nominal	Absence of brain, cardiac and respiratory function	0 = No 1 = Yes
Age	Demographic/Categorical	Length of time an individual has existed	Years of age defined as: 1 = < 55; 3 = 55 and older;
Gender	Demographic/Nominal/ Binary	Sex as self-identified by the patient	1 = Male 2 = Female
Race	Demographic/Categorical	Physical or genetic traits shared by a group and self-identified by patient	1 = White; 2 = Non-white;
Marital Status	Demographic/Categorical	Relationship status as self-identified by the patient	1 = Married; 2 = Not married (divorced, widowed, single);
Transfer to Higher Level of Care	Demographic/Categorical	Intensity of care required for patient following rapid response or cardiopulmonary resuscitation.	1 = Progressive Care Unit 2 = Intermediate Care Unit 3 = Intensive Care Unit 4 = None

Variable Name	Variable Type and Form	Theoretical/ Descriptive Definition	Operational Definition/Specification
Admission Diagnosis	Clinical/Nominal	Documented diagnosis at time of admission	1 = Medical diagnosis 2 = Surgical diagnosis
Telemetry Monitoring	Clinical/Nominal	Portable cardiac monitor worn continuously by patient	0 = No telemetry monitoring in place 1 = Telemetry monitoring in place

Table 2. Differences in Demographic and Clinical Characteristic Between Cardiopulmonary Resuscitation Events and Rapid Response Events

Variable	Total Sample n (%) 75 (100)	Rapid Response Event n (%) 29 (39%)	Cardiopulmonary Resuscitation Event n (%) 46 (61%)	Statistics Chi-Square (χ^2)	p Value
Age				.11	.78
• < 55	17 (22.7)	11 (64.7)	6 (35.3)		
• 55 and older	58 (77.3)	35 (60.3)	23 (39.7)		
Gender				1.7	.23
• Male	42 (56)	23 (54.8)	19 (45.2)		
• Female	33 (44)	23 (69.7)	10 (30.3)		
Race/Ethnicity				.63	.49
• White	65 (86.7)	41 (63.1)	24 (36.9)		
• Non-white	10 (13.3)	5 (50)	5 (50)		
Marital Status				.11	.81
• Married	38 (50.7)	24 (63.2)	14 (36.8)		
• Not Married (divorced, widowed, single)	37 (49.3)	22 (59.5)	15 (40.5)		
Admission Diagnosis				1.7	.20
• Medical diagnosis	53 (70.7)	35 (66)	18 (34)		
• Surgical diagnosis	22 (29.3)	11 (50)	11 (50)		
Telemetry Monitoring				1.0	.36
• No telemetry monitoring in place	70 (93.3)	44 (62.9)	26 (37.1)		
• Telemetry monitoring in place	5 (6.7)	2 (40)	3 (60)		
Death				7.2	.01
• No	68 (90.7)	45 (66.2)	23 (33.8)		
• Yes	7 (9.3)	1 (14.3)	6 (85.7)		

Table 3. Differences in Mean Rothman Index Score from Admission to Time of Event

	n (%)	Mean (SD)	t-test	p Value
RI Admission to Event			4.54	<0.001
• RI on Admission	75 (100)	57.97 (18.27)		
• RI at Time of Event	75 (100)	47.04 (19)		
RI 48 Before to Event			3.95	< 0.001
• RI 48 Hours Before Event	49 (65.3)	53.98 (16.45)		
• RI at Time of Event	49 (65.3)	44.17 (19.72)		
RI 24 Before to Event			4.60	<0.001
• RI at 24 Hours Before Event	59 (78.6)	52.62 (16.11)		
• RI at Time of Event	59 (78.6)	43.89 (19.10)		

Table 4. Rothman Index Change from Admission to Event By Death

Death	n (%)	Mean (SD)	t-test	p Value
No	68 (91)	11.09 (21.33)	.21	.83
Yes	7 (9)	9.34 (16.23)		