

Title

The Comparison of National Early Warning Score and Visensia Score Index as an
Activation Trigger for Rapid response systems in an outpatient setting.

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Disclosure

The authors have no conflicts of interest to declare.

Abbreviations

NEWS: National Early Warning Score, VSI: Visensia Score Index, HCU: High Care

Unit, ICU: Intensive Care Unit, AUC, area under the curve; AVPU scale, alert,

verbal, pain, unresponsive scale; CI, confidence interval;

Abstract

There have been solid triage systems to detect a critical-ill patient in-hospital setting using early warning systems. In an outpatient setting, there is no systematic ways to triage patients with serious condition. We conducted pilot study last year aimed to determine the performance of national NEWS among patients who activated RRS in an outpatient setting. In the result, the difference between the NEWS at the time of deterioration and at disposition might usefully predict admissions and poor clinical outcomes.

This single-center retrospective cohort study aimed to to investigate and compare efficacy of NEWS and VSI as a prediction tool and as an activation trigger for rapid response systems among whole first-visit patients of our internal medicine clinic. From June 1, 2018 to November 30, 2018 at a 350-bed teaching community hospital in Japan. Patient age and sex, and physiological measurements, NEWS, VSI as well as disposition and outcomes were collected. 3301 patients were included. One-hundred eight (3.3%), and 16 (0.5%), and 5 (0.2%) of the patients were admitted to a general ward, HCU, or ICU, respectively. The area under the curve (AUC) of NEWS for

admission, HCU or ICU admission, and ICU admission were 0.71 (95% Confidence interval : CI, 0.66 - 0.76); 0.88 (95% CI, 0.80 - 0.97); and 0.998 (95% CI, 0.996-1.0), respectively. AUC of VSI for admission, HCU or ICU admission, and ICU admission were 0.66 (95%CI, 0.60 - 0.71); 0.82 (95% CI, 0.71 - 0.93); and 0.97 (95% CI, 0.96-0.98), respectively. AUC of NEWS was significantly superior than AUC of VSI for admission and for ICU admission ($p = 0.03$, $p < 0.01$).

Introduction

Recently, there has been a considerable interest in strategies for detecting critically ill patient. Failure to recognize and respond patient deterioration may lead to increased hospital mortality, morbidity, and length of stay (Barwise et al., 2016). The rapid response system (RRS) has been developed and adopted internationally for timely identification and intervention of clinically deteriorating patients. RRS comprises both the afferent limb to notice patient at risk and activate the system, and the efferent limb to evaluate the patient and perform the necessary interventions by medical emergency team (MET) (DeVita et al., 2017). An implementation of RRS was known to be associated with a significant decrease in cardiac arrest and overall mortality of inpatients (DeVita et al., 2004), (Chan, Jain, Nallmothu, Berg, & Sasson, 2010), (Winters et al., 2013).

Essential of RRS afferent limb is a set of predetermined activation criteria. Conventionally, single-parameter criteria was commonly used in US and Australia. In single-parameter criteria, if any of the single parameter observation breach the criteria

threshold (eg, pulse rate, <40 or >120 beats/min) in addition to staff concerns, then MET should be called to the patient.

In late 1990s, the early warning score system (EWSS) was developed to more accurate detection of critically ill patient. The EWSS was designed to allocate points for a variety of vital signs and mental status and assess the sum of each point. In 2012, Standardized EWSS for the National Health Service was developed by the Royal College of Physicians: which is known as the national EWS (NEWS) {physicians:2017ty}. NEWS has been validated in general ward, ER, prehospital settings, and shown that it could be a useful tool for predicting unplanned ICU transfer, cardiac arrest, and short-term mortality within 48 hours. The visensia score index (VSI) is other type of EWSS that analyses 5 vital signs and produce a single patient score by specific software (National institute for health & excellence, 2015). One prospective, single-center, before-and-after study found that patients monitored with VSI had a significantly shorter duration of any cardio-respiratory instability and fewer episodes of serious and persistent instability (Hravnak, DeVita, Clontz, care, 2011, 2011).

The efficacy of Rapid response system(RRS) and EWSS among outpatient was very limited. We conducted pilot study last year aimed to determine the efficacy of a rapid response system and the performance of national NEWS among patients who activated RRS in an outpatient setting. In the result, the difference between the NEWS at the time of deterioration and at disposition might usefully predict admissions and poor clinical outcomes in RRS outpatient settings(Ehara et al., 2019).

However, the pilot study had several limitations. The study population was small sample size , exclusively comprised of RRS-activated outpatients and the results cannot be extrapolated to a general outpatient clinic population . Therefore, we conducted the study is to investigate and compare efficacy of NEWS and VSI as a prediction tool and as an activation trigger for rapid response systems among whole first-visit patients of our internal medicine clinic.

Methods

This prospective cohort study was conducted at a single-center study undertaken from June 1, 2018 to November 30, 2018 at a 350-bed teaching community hospital with a 14-bed ICU, a 12-bed high care unit (HCU). The study population was the patients who visited internal medicine outpatient clinic (not including cardiology clinic) at first time. Clinic nurses took a medical interview for every patient after they filled in the medical questionnaire. The nurses also evaluated their physiological measurements including respiratory rate, oxygen saturation, body temperature, systolic blood pressure, heart rate, and the level of consciousness. In the study period, they recorded NEWS based on the measurements.

We reviewed the medical questionnaires, medical records, and MET records and cases were identified. Patients who visited internal medicine outpatient clinic at first time were included. Patients whose any physical measurements were missing were excluded. Patient age and sex, and physiological measurements including respiratory rate, oxygen saturation, body temperature, systolic blood pressure, heart rate, and the level of consciousness graded using the AVPU scale (Alert; Verbal, voice response

present; Pain, pain response present; Unresponsive), NEWS, as well as disposition and outcomes were collected. Outcomes were hospital admission, unplanned HCU or ICU transfer, cardiac arrest, as well as 24-hour, 30-day, and 90-day mortality rates. The NEWS was calculated as reported by the Royal College of Physicians. The aggregated NEWS was categorized into three groups, as follows: a low-risk group (NEWS 0–4), a intermediate-risk group (NEWS 5–6), and a high-risk group (NEWS ≥ 7), according to NEWS threshold criteria.

RRS-activated outpatients were evaluated by an emergency physician-led MET, and transferred to the ER. Conventionally, our medical emergency team (MET) calling criteria is single parameter criteria (conventional criteria) based on the University of Pittsburgh Medical Center ‘Condition C’ calling criteria. From 1st September, we added NEWS to MET calling criteria. We activated RRS and call MET if patients met conventional criteria only (1st June to 31st August) and either conventional criteria or NEWS ≥ 5 : Intermediate risk or high risk (1st September to 30th November). The number of RRS activation was compared between pre and post period. In post period, whether activation criteria was conventional criteria or NEWS or

both, was recorded. We also evaluated VSI based on the vital signs retrospectively. The prediction efficacy of NEWS, and VSI for outcomes were analyzed using ROC curve. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) for admission, HCU or ICU admission, and ICU admission was also analyzed..

For data analysis, R (The R Foundation for Statistical Computing, Vienna, Austria, version 3.3.3) was used. A Mann-Whitney U test was used for statistical comparison of continuous variables between two groups, and A Kruskal-Wallis test was used for statistical comparison of continuous variables between three or more groups. A Fisher's exact test was used to analyze data involving categorical variables. DeLong's test was used for two correlated ROC curves data.

Results

There were 4542 outpatients who visited internal medicine outpatient clinic (not including cardiology clinic) at first time during the study period. Patients whose age, gender or any physiological parameter was missing were excluded. The numbers of missing data of each variables are 73 (age), 54 (gender), 45 (BT), 41 (HR), 44 (BP), 1184 (RR), and 1093 (SpO2). In the result, 1241 patients were excluded, and 3301 patients were included to analyze.

Patient characteristics are shown in Table 1. The median age was 53 years (IQR (interquartile range), 37 –71 years). The male gender was 1677 (50.8%). The median NEWS was 1.0 (IQR, 0-1.0), and the median VSI was 0.9 (IQR, 0.6-1.0). The NEWS percentages in the low-risk, medium-risk, and high-risk groups were 98.5%, 0.9%, and 0.6%. The percentage of $VSI \geq 3$ was 4.5%. One-hundred eight (3.3%), and 16 (0.5%), and 5 (0.2%) of the patients were admitted to a general ward, HCU, or ICU, respectively. Twenty-four-hour, 30-day, and 90-day mortality rates were 0%, 0.1%, and 0.1%, respectively. Thirty for (1.0%) patients activated RRS. All patients who activated

RRS were transferred to the ER and were evaluated by an emergency physician-led

MET, according to our hospital RRS protocol.

The NEWS based on admission status (admission vs discharge) and disposition (discharge vs ward, HCU, ICU) was shown in Figure 1. The NEWS for patients who required admission was significantly higher than for patients who were discharged (median score, 0 (IQR 0, 1) vs 1(IQR 1, 4), $p < 0.01$). The median NEWS of patients who admitted ward, HCU, and ICU were 1(IQR 1, 3), 2 (IQR 1.75, 6.25), and 8 (IQR 7, 10) respectively ($p < 0.01$). The VSI based on admission status (admission vs discharge) and disposition (discharge vs ward, HCU, ICU) was shown in Figure 2.

The VSI for patients who required admission was significantly higher than for patients who were discharged (median score, 0.9 (IQR 0.6, 1.4) vs 1.5(IQR 0.7, 2.8), $p < 0.01$).

The median VSI of patients who admitted ward, HCU, and ICU were 1.2(IQR 0.65, 2.4), 1.9 (IQR 1.18, 4.7), and 3.6 (IQR 3.3, 3.7) respectively ($p < 0.01$).

The NEWS and VSI category and disposition was shown in Table 2.

NEWS intermediate and high risk were significantly associated for admission, HCU or ICU admission, and ICU admission ($p < 0.01$, $p < 0.01$, and $p < 0.01$). $VSI \geq 3$ was

also significantly associated for admission, HCU or ICU admission, and ICU admission ($p < 0.01$, $p < 0.01$, and $p < 0.01$). NEWS intermediate or high risk could detect 22% (28/129) , 48% (10/21) and 100% (5/5) of patients required general ward , HCU and ICU admissions respectively. VSI high risk also detected 22% (28/128) , 48% (10/21) and 80% (4/5) of patients required general ward , HCU and ICU admissions respectively (Table 2).

Figure 3 shows ROC curve of NEWS and VSI for clinical outcomes. The area under the curve (AUC) of NEWS for admission, HCU or ICU admission, and ICU admission were 0.71 (95% Confidence interval : CI, 0.66 - 0.76); 0.88 (95% CI, 0.80 - 0.97); and 0.998 (95% CI, 0.996-1.0), respectively. AUC of VSI for admission, HCU or ICU admission, and ICU admission were 0.66 (95%CI, 0.60 - 0.71); 0.82 (95% CI, 0.71 - 0.93); and 0.97 (95% CI, 0.96-0.98), respectively. AUC of NEWS was significantly superior than AUC of VSI for admission and for ICU admission ($p = 0.03$, $p < 0.01$). AUC of NEWS was tend to superior, but not significant than AUC of CSI for HCU or ICU admission ($p = 0.07$). The best threshold value of NEWS by ROC curve for admission, HCU or ICU admission, and ICU admission were 2.0, 2.0,

and 7.0 respectively. The best threshold value of VSI by ROC curve for admission, HCU or ICU admission, and ICU admission were 1.7, 1.7, and 2.8 respectively. Table 3 and Table 4 shows the validity of NEWS and VSI for clinical outcomes for variable cut off point.

The number of RRS activation was 17 in pre period (1st June to 31th August) and 17 in post period (1st September to 30th November). The percentage of RRS activation was not significantly increased in post period compared to pre period (17/1461: 1.1% vs 17/1810: 0.9%, $p = 0.61$). Only 2 patients activated RRS triggered by NEWS, not by conventional criteria.

Discussion

To identify patient deterioration is important. While the majority of outpatients is not required admission, a very limited number of critically ill patients who required ICU-level intervention exist even in an outpatient setting. Triage systems and RRS are not well established in an outpatient setting than in emergency room setting or an inpatient setting because outpatients are very low risk group for clinical deterioration than in-hospital patients or ER patients. In our result, 3.9% of patients admitted to hospital among the first-visit patients in internal medicine outpatient clinic. HCU and ICU admission was only 0.5% and 0.2%. NEWS categorized intermediate or high risk for 1.5%, and VSI >3 was 4.5%. General ward was the most common admission site. Prediction of hospital admission may promote decision making of disposition and be useful for outpatient floor management. However, early detection and timely intervention is most necessary for critically ill patients who required ICU admission. In such patients, delays in intervention will led to increase length of ICU stay and high mortality (Barwise et al., 2016). It is also well known that in patients with sepsis,

mortality increases with each 1 hour delay in antibiotic administration (Ferrer et al., 2014; Kumar et al., 2006).

This is the first study evaluating the NEWS and VSI for patients who visited internal medicine outpatient clinic at first time. Our results showed that both the NEWS and VSI could predict hospital admission (AUC 0.71, 0.66), HCU or ICU admission (AUC 0.88, 0.82), and ICU admission (0.99, 0.97). In previous study in an inpatient setting, NEWS has a greater ability to discriminate patients at risk of the combined outcome of cardiac arrest, unanticipated ICU admission or death within 24 h. (the AUC : 0.873 95%CI 0.866–0.879). In our result, both scores revealed high accuracy for predicting HCU or ICU admission, especially ICU admission.

AUC of NEWS was significantly superior than AUC of VSI for predicting hospital admission and for ICU admission ($p = 0.03$, $p < 0.01$, figure3). VSI uses five physiological parameters : BT, BP, HR, RR, SpO₂. On the other hand, NEWS uses seven parameters: BT, BP, HR, RR, SpO₂, mental status, and oxygen use. Using two more parameter may be one of the reason why accuracy of prediction of NEWS was superior than that of VSI. AUC of NEWS was significantly superior than AUC of VSI

for predicting hospital admission and for ICU admission ($p = 0.03$, $p < 0.01$, figure3).

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NEWS was superior than that of VSI.

NEWS requires manual evaluation and calculation because the parameter includes mental status and oxygen use. However, in our study population ($n = 3301$), only 9 patients had altered mental status and only 2 patients had supplemental oxygen use. The prevalence of these two parameters were quite low and the influence of validity for clinical outcome was very little. Therefore, evaluating NEWS for a number of patients may lead to workload to healthcare staffs. On the other hand, VSI couldn't be calculated manually and required specific device because of highly complex mathematical formula. VSI is designed for automatic calculation by using special healthcare equipment. From this stand point, VSI might be more convenient tool for mass screening in an outpatient setting.

In terms of maximum of the sum of sensitivity and specificity, the best cutoff value for hospital admission was 2 for NEWS and 1.7 for VSI. However, for implementation in clinical setting require positive predictive value and negative predictive value should be considered. Prevalence of critically ill patient is quite low in an outpatient setting. At cutoffs of 2 for NEWS 2 and VSI 2.0, the each positive predictive values for admission are only 11% and 11%. Low positive predictive value can lead to excessive staff workload. High negative predictive value means low risk of missing serious outcomes. The best cutoff value for ICU admission was 7 for NEWS and 2.8 for VSI. As for NEWS 7.0, PPV for ICU admission was 26%. On the other hand, at cut off 3.0 for VSI, PPV for ICU admission was only 3%. To organize effective RRS, the balance between trigger rate and risk of missing outcomes is important. (Smith et al., 2016). The Royal College of Physicians has recommended that medium-risk group patients (NEWS 5-6 points) should be observed and monitored closely and assessed urgently by a clinician or team with core competencies in the care of acutely ill patients. It has also been recommended that high- risk patients (NEWS ≥ 7 points) should be assessed by a team with critical care competencies, including a practitioner with

advanced airway management skills, and considered for transfer to an HCU or an ICU based on previous report in an inpatient setting and in an ER setting. In this study, we revealed prediction validity of NEWS and VSI among outpatient setting. NEWS intermediate or high risk, and VSI high risk might be reasonable MET calling criteria. Eventually, the goal of RRS is not prediction or detection only. Improvement of clinical outcome resulted from timely intervention by efficient system should be investigated in the future.

Limitations

There are some limitations in our study. First, this was a single-facility retrospective study. Second, 1241 patients were excluded because of insufficient vital sign data, mainly respiratory rate or oxygen saturation. Finally, the study population was exclusively comprised of first visit outpatients at internal medicine clinic without cardiology clinic ; therefore, our results cannot be extrapolated to a general outpatient clinic population.

Conclusion

Our results validated the NEWS and VSI in outpatient setting.

Both score revealed high efficacy for predicting HCU or ICU admission, especially ICU admission in o. NEWS was significantly superior than VSI for predicting hospital admission and for ICU admission ($p = 0.03$, $p < 0.01$).

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Table1. Patient characteristics (n = 3301)

| | |
|---------------------------------------|---------------|
| Age in years, median (IQR) | 53 [37-71] |
| Male gender, n (%) | 1677 (50.8) |
| NEWS, median (IQR) | 1.0[0- 1.0] |
| NEWS category on deterioration, n (%) | |
| Low risk 0-4 | 3253 (98.5) |
| Moderate risk 5-6 | 29 (0.9) |
| High risk 7 \geq | 19 (0.6) |
| VSI, median (IQR) | 0.9 [0.6-1.0] |
| VSI category, n (%) | |
| Low risk 0-3.0 | 3141 (95.5) |
| High risk 3.0 \geq | 149(4.5) |
| NA | 11 |
| RRS activation, n (%) | 34 (1.0) |
| Dispositions n (%) | |
| Admission | 129 (3.9) |
| General ward | 108 (3.3) |
| HCU | 16 (0.5) |
| ICU | 5 (0.2) |
| 24 hour mortality, n (%) | 0 |
| 30 day mortality, n (%) | 2(0.1) |
| 90 day mortality, n (%) | 4(0.1) |

IQR: Inter Quantile Range, NEWS: National Early Warning Score, VSI: Visensia Score Index, RRS: Rapid Response System, ICU: Intensive Care Unit, HCU: High Care Unit

Table 2. NEWS and VSI category and disposition

| NEWS category | | | | |
|--------------------------------|----------------------------|---------------------------------|---------------------|---------|
| | Low risk n = 3253 | Intermediate risk n = 29 | High risk n = 19 | p value |
| Hospital admission, n(%)n=129 | 101(3.1) | 12(41.4) | 16(84.2) | <0.01 |
| HCU or ICU admission, n(%)n=21 | 11(0.3) | 1(3.4) | 9(47.4) | <0.01 |
| ICU admission, n(%)n=5 | 0 | 0 | 5(26.3) | <0.01 |
| VSI category | | | | |
| | Low risk 0-3.0 n = 3141 | High risk $3.0 \geq$ n = 149 | | |
| Hospital admission n(%) n=129 | 100(3.2) | 28(18.8) | | <0.01 |
| HCU or ICU admission n(%) n=21 | 11(0.4) | 10(6.7) | | <0.01 |
| ICU admission n(%) n=5 | 1(0.03) | 4(2.7) | | <0.01 |

NEWS: National Early Warning Score. VSI: Visensia Score Index,

HCU: High Care Unit, ICU: Intensive Care Unit,

Table 3. Validity of NEWS among outpatient RRS cases

| NEWS Cut off NEWS =2 | | | | |
|----------------------|-----|-----|-----|-----|
| | Sen | Spe | PPV | NPV |
| Hospital admission | 50 | 84 | 11 | 98 |
| HCU or ICU admission | 81 | 83 | 3 | 100 |
| ICU admission | 100 | 83 | 1 | 100 |
| NEWS Cut off NEWS =5 | | | | |
| | Sen | Spe | PPV | NPV |
| Hospital admission | 22 | 99 | 59 | 97 |
| HCU or ICU admission | 48 | 99 | 21 | 100 |
| ICU admission | 100 | 99 | 10 | 100 |
| NEWS Cut off NEWS =7 | | | | |
| | Sen | Spe | PPV | NPV |
| Hospital admission | 13 | 99 | 85 | 97 |
| HCU or ICU admission | 45 | 100 | 50 | 100 |
| ICU admission | 100 | 100 | 26 | 100 |

NEWS: National Early Warning Score. HCU: High Care Unit, ICU: Intensive Care Unit, Sen: sensitivity, Spe: specificity, PPV: positive predictive value, NPV: negative predictive value, AUC: area under the curve.

Table 4. Validity of VSI among outpatient RRS cases

| VSI Cut off NEWS = 2.0 | | | | |
|------------------------|-----|-----|-----|-----|
| | Sen | Spe | PPV | NPV |
| Hospital admission | 39 | 87 | 11 | 97 |
| HCU or ICU admission | 57 | 87 | 3 | 100 |
| ICU admission | 100 | 87 | 1 | 100 |
| VSI Cut off NEWS = 2.5 | | | | |
| | Sen | Spe | PPV | NPV |
| Hospital admission | 28 | 93 | 14 | 97 |
| HCU or ICU admission | 52 | 93 | 4 | 100 |
| ICU admission | 100 | 92 | 2 | 100 |
| VSI Cut off NEWS = 3.0 | | | | |
| | Sen | Spe | PPV | NPV |
| Hospital admission | 22 | 96 | 19 | 97 |
| HCU or ICU admission | 48 | 96 | 7 | 100 |
| ICU admission | 80 | 96 | 3 | 100 |

VSI: Visensia Score Index, HCU: High Care Unit, ICU: Intensive Care Unit, Sen: sensitivity, Spe: specificity, PPV: positive predictive value, NPV: negative predictive value, AUC: area under the curve.

Figure legend. Figure1. The NEWS based on admission status (admission vs discharge
Figure1A) and disposition (discharge vs ward, HCU, ICU, Figure 1B)

Figure1A

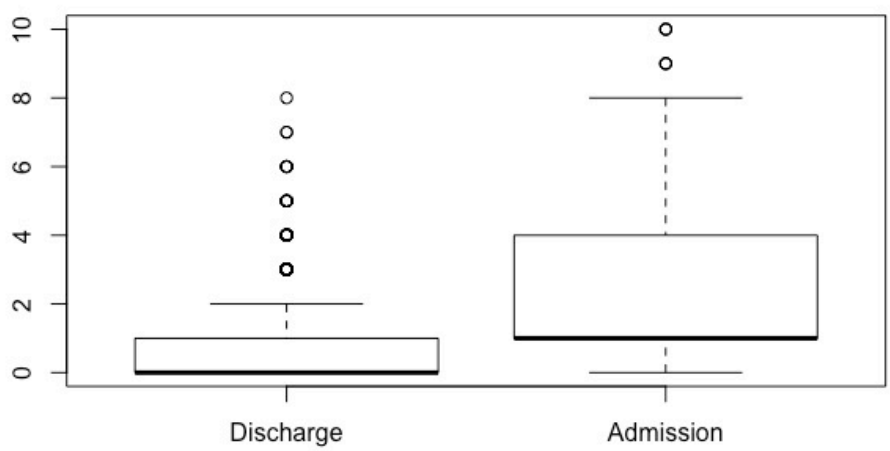


Figure1B

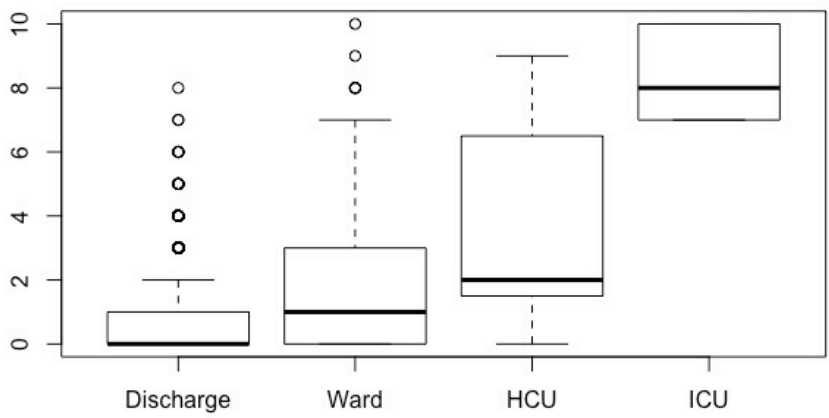


Figure2. The VSI based on admission status (admission vs discharge Figure2A) and disposition (discharge vs ward, HCU, ICU, Figure 2B)

Figure2A

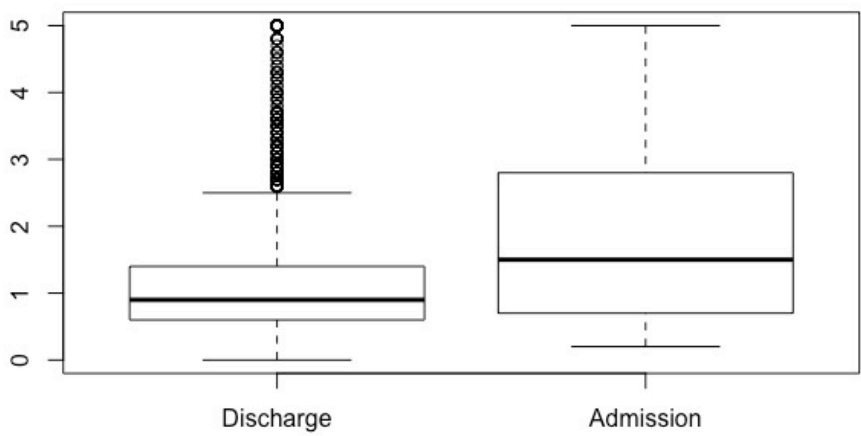


Figure2B

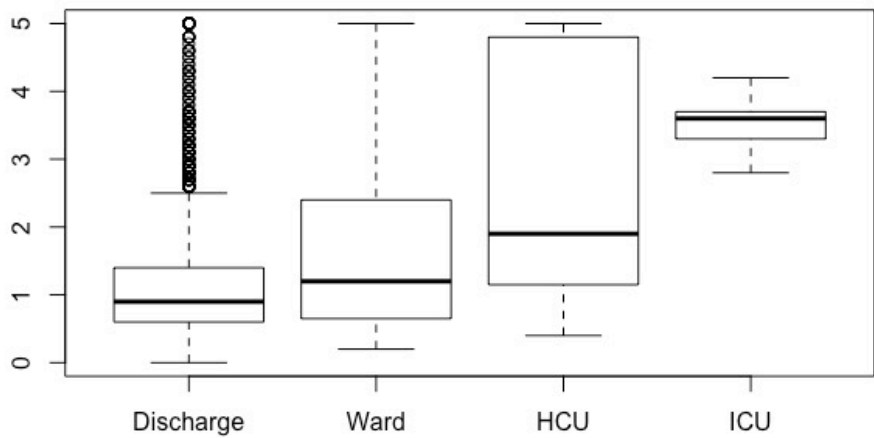


Figure3. ROC curve of NEWS and VSI for clinical outcomes

