Beyond Triage: The Diagnostic Accuracy of Emergency Department Nursing Staff Risk Assessment in Patients with Suspected Acute Coronary Syndromes.

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ABSTRACT

Objectives

To establish the accuracy of emergency department (ED) nursing staff risk-assessment, using an established chest pain risk score alone and when incorporated with presentation high-sensitivity troponin testing as part of an accelerated diagnostic protocol (ADP).

Design

Prospective observational study comparing nursing and physician risk-assessment using the modified Goldman (m-Goldman) score and a pre-defined ADP, incorporating presentation high-sensitivity troponin.

Setting

A U.K. District ED.

Patients

Consecutive patients, aged ≥18, with suspected cardiac chest pain and non-ischaemic ECG, for whom the treating physician determined serial troponin testing was required.

Outcome Measures

30 day major adverse cardiac events (MACE).

Results

960 participants were recruited. 912/960 (95.0%) had m-Goldman scores recorded by physicians and 745/960 (77.6%) by nursing staff. The AUC of the m-Goldman score in

predicting 30 day MACE was 0.647 (95% CI 0.594-0.700) for physicians and 0.572 (95% CI 0.510-0.634) for nursing staff (P=0.09). When incorporated into an ADP, sensitivity for the rule-out of MACE was 99.2% (95% CI 94.8-100) and 96.7% (90.3-99.2) for physicians and nurses respectively. One patient in the physician group (0.3%), and three patients (1.1%) in the nursing group were classified as low-risk yet had MACE.. There was fair agreement in the identification of low-risk patients (kappa 0.31, 95% CI 0.24-0.38).

Conclusion

The diagnostic accuracy of ED nursing staff risk-assessment is similar to that of ED physicians and inter-observer reliability between assessor groups is fair. When incorporating high-sensitivity troponin testing, a nurse-led ADP has a miss-rate of 1.1% for MACE at 30 days.

What is already known on this subject? Few studies have investigated the role of nursing staff in the assessment of low-risk patients with chest pain. Advanced nursing interventions during initial patient assessment have been proven to reduce time to treatment and diagnosis, improve patient flow through the ED and reduce length of stay across a wide variety of emergency presentations. Nursing staff may therefore be an underutilized resource in mitigating crowding.

What this study adds? This prospective, single-centre observational study demonstrates that emergency department nursing staff risk assessment, using an established chest pain risk score is similar to that of emergency department physicians. When combining nursing risk-stratification with presentation high-sensitivity troponin testing, a nurse-led accelerated discharge protocol would have a miss-rate of 1.1% for MACE at 30 days. This finding, together with fair inter-observer reliability of nursing and physician assessments in the identification of low-risk patients, suggests the future role of nursing staff in rapid rule-out pathways holds promise.

Keywords

Nursing

Chest Pain

Acute Coronary Syndrome

Emergency Department

Sensitivity and Specificity

INTRODUCTION

Chest pain is one of the most common complaints of patients presenting to the emergency department (ED), with approximately one million visits per year in the UK. The majority of patients require prolonged assessment prior to safe discharge despite the fact that only 15-25% of these patients have a final diagnosis of acute coronary syndrome (ACS).[1] Recently, accelerated diagnostic protocols (ADPs) have successfully incorporated chest pain risk scores with early biomarker testing to identify those patients at low-risk of major adverse cardiac events (MACE) who may be suitable for early discharge.[2-6]

Advanced nursing interventions during initial patient assessment have been proven to reduce time to treatment and diagnosis, improve patient flow through the ED and reduce length of stay across a wide variety of emergency presentations.[7] It is also evident that chest pain-specific risk scores, such as a modified TIMI score,[8] can improve the accuracy of nursing assessments.[9] Yet, the ability of ED nursing staff to safely risk-stratify low-risk patients with suspected ACS who may be suitable for early rule-out biomarker testing and therefore early discharge has never been investigated. Consequently, ED nursing staff remain a potentially underused resource in the assessment of chest pain.

This study aimed to establish the diagnostic accuracy of ED nursing staff risk assessment, using an established chest pain risk score (modified Goldman) alone and when incorporated with presentation high-sensitivity troponin testing as part of a nurse-led accelerated

diagnostic protocol. The secondary aim was to evaluate the inter-observer reliability of nursing and physician assessments within the modified Goldman risk score.

METHODS

This prospective observational clinical trial was designed to assess the pre-defined Triage Rule-out Using high-Sensitivity Troponin (TRUST) ADP. This ADP incorporates a non-ischaemic ECG, a modified Goldman (m-Goldman) risk score,[10] and a single presentation high-sensitivity troponin (hs-cTnT) result (Table 1). The study protocol was designed to be truly pragmatic in order to enhance the widespread applicability of the study results:[11] treating ED physicians and nursing staff performed m-Goldman risk scores, real-time sample processing and 24/7 recruitment. Results from physician assessment using the TRUST ADP have been published previously.[6] The study was designed using the Standards for Reporting Diagnostic Accuracy (STARD),[12] and approved by the U.K. National Research Ethics Service. All patient participants and nursing staff provided written informed consent. The TRUST study was registered with the Controlled Trials Database (ISRCTN No. 21109279).

Table 1. The Modified Goldman Score and the TRUST ADP

MODIFIED GOLDMAN RISK SCORE	*1 point for each variable present*
Typical new onset chest pain at rest	
Pain the same as previous myocardial infarction	
Pain not relieved by Glyceryl Trinitrate (GTN) Spray within 15 minutes	
Pain lasting more than 60 minutes	
Pain occurring with increasing frequency	
Hypotension (Systolic Blood Pressure <100mmHg)	
Acute shortness of breath	
Pain within 6 weeks of a myocardial infarction or revascularisation	
Modified Goldman Total:	
TRUST ACCELERATED DIAGNOSTIC PROTOCOL (TRUST ADP)	
Low risk* (Suitable for discharge)	1. Modified Goldman Score ≤1 2. Non-ischaemic ECG 3. Presentation high-sensitivity troponin T <14ng/L
Not Low Risk	1. Modified Goldman Score >1 2. Ischaemic ECG 3. Presentation high-sensitivity troponin T ≥14ng/L
****Safety Point:*** *Protocol not validated in age ≥80 years*	

Study Setting, Recruitment and Data Collection

Poole NHS Foundation Trust is a U.K. District General, the ED has approximately 62 000 new patient attendances per year. Patients with suspected ACS are managed according to the local hospital protocol, which involves risk assessment by ED physician staff using the m-Goldman risk score and blood drawn for hs-cTnT at 6 hours after presentation. As part of the study protocol, blood was also taken at presentation for hs-cTnT analysis. Whilst historical clinical protocols, at the time of this study, did not include troponin measurement

at presentation, this had the benefit of ensuring that treating physicians were blinded to the initial hs-cTnT result to avoid selection bias and observation bias.[13]

The fifth generation Roche ELECSYS hs-cTnT assay (Roche, Switzerland) which has a 99th percentile of 14ng/L and 10% coefficient of variation of <10% at 9ng/L, was used for both presentation and reference (6-hour) samples. During initial assessment clinical staff drew blood for routine admission samples and an additional 3.5mls of whole blood in a pre-labelled study specific serum settling tube for hs-cTnT analysis. All serum samples were tested in real time.

Consecutive patients attending the ED with suspected ACS were prospectively screened from July 2012 to August 2013. Patients were included if they were ≥18 years of age and had at least 5 minutes of chest pain suggestive of ACS, and for whom the treating physician determined inpatient evaluation was required. No patient was observed within the ED to await 6-hour blood draws, due to the UK national healthcare target that patients must be seen, treated, admitted or discharged within 4 hours. Possible cardiac symptoms included acute chest, epigastric, neck, jaw or arm pain, or discomfort or pressure without an apparent non-cardiac source, in accordance with the American Heart Association case definitions.[14] Patients were excluded if any of the following were present: STEMI or left bundle branch block not known to be old, ECG changes diagnostic of ischaemia (ST segment depression ≥1mm or T-wave inversion consistent with the presence of ischaemia), arrhythmias (new-onset atrial fibrillation, atrial flutter, sustained supraventricular tachycardia, second-degree or complete heart block, or sustained or recurrent ventricular arrhythmias), hs-cTnT not suitable for analysis (e.g. haemolysis), age ≥80 years, atypical

symptoms in the absence of chest discomfort, a clear non-ACS cause for chest pain was found at presentation (e.g. pulmonary embolism, pneumonia, aortic dissection), another medical condition requiring hospital admission, refusal or inability to give informed consent, non-English speaking, pregnancy, renal failure requiring dialysis or inability to be contacted after discharge.

ED physician staff undertook initial ECG evaluation as part of clinical care, later confirmed by two local cardiologists (nursing staff were not expected to undertake ECG evaluation). Patients with ECG evidence of acute myocardial infarction or acute ischaemia were immediately defined as high risk in accordance with Goldman's original rule and therefore not recruited.

Data were collected prospectively using a published data dictionary.[15] ED nursing staff undertaking initial assessment were asked to record the m-Goldman risk score on a case report form, at the time of patient presentation to the ED. Nursing staff were experienced in the primary assessment and triage of ED patients with chest pain but had no formal training in the use of the m-Goldman score. Consequently they were provided with written explanatory notes on how to complete the risk score. The nursing risk score was kept separate from the clinical notes in a colored envelope and removed by a member of the research team at the earliest opportunity. Attending ED physicians completed an identical m-Goldman risk score as part of routine clinical assessment on a separate clinical assessment form.

Follow-up was undertaken by independent review of hospital electronic patient records, summary of health records from the patient's General Practitioner (GP) obtained at least 6-months after attendance and a national clinical records search (which identifies death). Where a participant had not attended hospital follow-up and/or a GP had failed to provide a health record/not GP-registered, the patient was regarded as lost to follow-up.

Index Tests

The index test was the m-Goldman score evaluated by both physicians and ED nursing staff. In order to establish the potential diagnostic accuracy of the m-Goldman score within a nurse-led ADP, the secondary index test of the TRUST ADP was used. This defined a patient as 'low-risk' if all of the following conditions were satisfied at presentation: An m-Goldman Score of ≤1 (Table 1), a non-ischaemic ECG and a single central laboratory hs-cTnT of <14ng/L.

Outcome Measures

The endpoint was the presence of major adverse cardiac events (MACE) occurring within 30 days of hospital attendance (including the index visit). MACE included: death due to ischaemic heart disease, cardiac arrest, symptom-induced revascularisation, cardiogenic shock, ventricular arrhythmia, high-degree atrioventricular block needing intervention and acute myocardial infarction (AMI). This definition is consistent with previous large scale research analyzing the diagnostic accuracy of ADPs.[3]

The presence of AMI was defined according to the Third Universal Definition of MI which states that a rise and/or fall in troponin, with at least one value above the 99th centile value in the context of a patient with ischaemic symptoms or signs (ECG changes or imaging

evidence) would satisfy the diagnosis.[16] Based on current consensus guidance for high-sensitivity troponin assays, a rise or fall of 20% (delta) was considered statistically significant and consistent with a diagnosis of AMI.[17] Adjudication of the primary endpoint was carried out by two local cardiologists blinded to the nursing m-Goldman score but whom had access to the clinical record, ECG and serial hs-cTnT results.

Statistical Analysis

Chi-squared analyses were used to generate 2 x 2 tables for the calculation of sensitivity, specificity, and positive and negative likelihood ratios. Receiver-operating characteristic curves were generated from sensitivity and specificity to give an overall summary of diagnostic accuracy. Significance was calculated using the Fisher's exact test for contingency tables and Mann-Whitney U test for non-parametric data; all reported p-values are two-tailed. Inter-observer reliability was assessed using Cohen's kappa. Statistical analysis was carried out using SPSS version 20.

RESULTS

Of 1096 eligible patients, 964 were recruited; 4 patients were lost to follow-up meaning that 99.6% were successfully monitored for 30 days. 132 patients were eligible, but not recruited due to missing the consent process, these were similar in age, gender and risk factors (P>0.05 for all). 124/960 patients (12.5%) had the outcome event MACE within 30 days. Figure 1 is a STARD diagram depicting a participant recruitment flow chart according to physician and nursing assessments. 912/960 (95.0%) had m-Goldman scores recorded by ED physicians and 745/960 (77.6%) by nursing staff.

There were no significant differences between physician and nursing patient-groups in age, gender, risk factors for coronary artery disease, prior cardiovascular history and hospital length of stay (P>0.05 for all) (Table 2).

Table 2. Patient Demographics

	Physician Assessed (n=912)	Nursing Assessed (n=745)	Significance of the difference between Physician and Nursing groups
Age, years: Mean (SD)	58.0 (13.3)	58.0 (13.2)	P=1.00
Sex n male (%)	546 (59.9)	431 (57.9)	P=0.41
Ethnicity n White British (%)	869 (95.3)	714 (95.8)	P=0.59
Risk factors n (%)			
Hypertension	505 (55.4)	409 (54.9)	P=0.85
Hyperlipidaemia	601 (65.9)	488 (65.5)	P=0.87
Smoking Current	219 (24.0)	182 (24.4)	P=0.84
Diabetes	152 (16.7)	120 (16.1)	P=0.76
Family History of CAD	340 (37.3)	280 (37.6)	P=0.90
Medical History			
Angina	238 (26.1)	187 (25.1)	P=0.64
Myocardial Infarction	194 (21.3)	159 (21.3)	P=0.97
Percutaneous Coronary Intervention	173 (19.0)	133 (17.9)	P=0.56
Congestive Cardiac Failure	27 (3.0)	21 (2.8)	P=0.86
Atrial Arrhythmia	115 (12.6)	91 (12.2)	P=0.81
Stroke/TIA	62 (6.8)	50 (6.7)	P=0.94
Length of Stay: Median (IQR)	18.7 (32.3)	18.3 (25.0)	P=0.82

Diagnostic Accuracy of Nursing Staff Risk-Assessment Using the m-Goldman Score

Contingency tables showing the occurrence of MACE according to index tests are available as Online Supplementary Data. The primary aim of the m-Goldman score is to identify low-risk patients who may be suitable for discharge, therefore the test metric of interest is sensitivity (rule-out). Table 3 demonstrates a sensitivity for the diagnosis of 30 day MACE of 73.9% (95%CI 65.5-81.1) and 63.0% (95%CI 53.0-72.3) for physicians and nursing staff respectively, when using the rule-out m-Goldman cut-off of ≤1.

Using the area under the curve (Figure 2) as an estimate of the overall diagnostic accuracy of the m-Goldman score in predicting 30 day MACE, there was no significant difference between assessor groups: 0.647 (95% CI 0.594-0.700) for physicians and 0.572 (95% CI 0.510-0.634) for nursing staff assessments (P=0.09).

Diagnostic Accuracy of the TRUST ADP

Table 3 also presents the statistical analysis of the TRUST ADP for predicting MACE at 30 days according to assessor groups. One patient in the physician group (0.3%), and three patients (1.1%) in the nursing group were classified as low risk by the ADP yet had MACE at 30 days. Sensitivity of the ADP for the rule-out of MACE was 99.2% (95% CI 94.8-100) and 96.7% (90.3-99.2) for physician and nursing groups respectively.

Table 3. Diagnostic Accuracy of the m-Goldman score and the TRUST ADP for predicting MACE at 30 days according to assessor groups.

	Presentation hsTnT <14ng/L	Physician m-Goldman Score ≤1	Nurse m-Goldman Score ≤1	Physician TRUST ADP	Nurse TRUST ADP
Number of Patients Assessed	960	912	745	912	745
Number of low risk patients with 30-day MACE missed (%)	24/766 (3.1)	31/426 (7.3)	34/328 (10.4)	1/355 (0.3)	3/264 (1.1)
Sensitivity	80.6 (73.3-86.6)	73.9 (65.5-81.1)	63.0 (53.0-72.3)	99.2 (94.8-100)	96.7 (90.3-99.2)
Negative predictive value	96.9 (95.7-97.8)	92.7 (90.4-94.7)	89.6 (86.8-92.2)	99.7 (98.3-100)	98.9 (96.6-99.7)
Specificity	88.8 (87.7-89.6)	49.8 (48.5-50.9)	45.0 (43.6-46.3)	44.6 (44.0-44.8)	40.0 (39.1-40.3)
Positive predictive value	51.5 (46.9-55.3)	18.1 (16.0-19.9)	13.9 (11.7-15.9)	21.2 (20.3-21.4)	18.5 (17.3-19.0)
Negative Likelihood Ratio	0.22 (0.15-0.30)	0.52 (0.37-0.71)	0.82 (0.60-1.08)	0.02 (0.00-0.12)	0.08 (0.02-0.25)
Positive Likelihood Ratio	7.17 (5.95-8.35)	1.47 (1.27-1.65)	1.15 (0.94-1.35)	1.79 (1.69-1.81)	1.61 (1.48-1.66)

Inter-observer reliability

Table 4 summarizes inter-observer reliability of individual components of the m-Goldman score and those patients identified as low-risk (m-Goldman ≤1). The degree of reliability varied with four components showing fair agreement, three showing moderate agreement and only one showing substantial agreement (though the finding of pain within 6 weeks of an AMI or revascularization was only present in 1.1% of the population). Using the m-Goldman score, there was fair agreement in the identification of low-risk patients between physicians and nursing staff (kappa 0.31, 95% CI 0.24-0.38).[18]

Table 4. Inter-observer reliability of the m-Goldman score

Clinical Feature	Proportion of patients with finding n (%) (Physician n=912)	Proportion of patients with finding n (%) (Nursing n=745)	Significance of difference	Kappa	95% Confidence Interval	Level of agreement (after Landis).[18]
Typical new onset chest pain at rest	394 (43.2)	299 (40.1)	P=0.21	0.22	0.15-0.30	Fair
Pain the same as previous AMI	115 (12.6)	75 (10.1)	P=0.11	0.53	0.43-0.63	Moderate
Pain not relieved by Glyceryl Trinitrate Spray within 15 minutes	166 (18.2)	133 (18.0)	P=0.85	0.54	0.46-0.62	Moderate
Pain lasting more than 60 minutes	537 (58.9)	472 (63.4)	P=0.06	0.38	0.31-0.44	Fair
Pain occurring with increasing frequency	140 (15.4)	146 (19.6)	P=0.02	0.23	0.14-0.32	Fair
Hypotension (Systolic BP <100mmHg	23 (2.5)	16 (2.1)	P=0.62	0.43	0.22-0.64	Moderate
Acute shortness of breath	167 (18.3)	177 (23.8)	P=0.007	0.26	0.18-0.34	Fair
Pain within 6 weeks of AMI or revascularization	10 (1.1)	8 (1.1)	P=0.97	0.80	0.58-1.00	Substantial
Low-risk patients (m-Goldman ≤1)	426 (46.7)	328 (44.0)	P=0.28	0.31	0.24-0.38	Fair

DISCUSSION

This study demonstrates that the diagnostic accuracy of ED nursing staff risk assessment, using an established chest pain risk score is similar to that of ED physicians. When combining nursing risk-stratification with presentation high-sensitivity troponin testing, a nurse-led ADP would have a miss-rate of 1.1% for MACE at 30 days. This finding, together with fair inter-observer reliability of nursing and physician assessments in the identification of low-risk patients, suggests the future role of nursing staff in rapid rule-out pathways holds promise.

Few studies have investigated the role of nursing staff in the assessment of low-risk patients with suspected ACS and this is the first to compare the assessments of physician and nursing staff using an ADP designed specifically to identify patients suitable for early discharge. Chest pain in the acute setting is traditionally triaged as a high-risk presentation,[19] consequently this cohort of patients are nursed in high-acuity areas, despite the fact that few patients (only 12.5% of our study population) have major adverse outcomes. It has been established that the interventions of nursing staff are important in improving the care of high-risk patients with chest pain.[20] However, our results also suggest that risk assessment by nursing staff with a focus upon low-risk patients, may be a viable strategy with the potential to improve ED efficiency, through early biomarker testing and the use of low acuity clinical areas.

This study is also important in highlighting inter-observer reliability of chest pain assessment, which remains under-reported in the literature. The m-Goldman risk score uses elements of chest pain history to identify those patients without unstable features, it

therefore requires some clinical judgment and subjectivity in interpretation. All nursing participants were experienced in the primary assessment of ED patients with chest pain. Therefore the only fair agreement between assessors may be seen as unexpected. This finding will not be limited to the m-Goldman score, as other commonly used risk scores also incorporate elements which require clinical judgment. Examples include the History, ECG, Age, Risk factors and Troponin (HEART) Score,[2] Manchester Acute Coronary Syndromes (MACS) rule,[4] and Vancouver chest pain rule.[5]

The ED nursing staff who took part in our analysis were all experienced in the primary assessment of ED patients with chest pain, however none were trained as advanced practitioners and they had no formal training in the use of the m-Goldman score, other than written instructions provided. Therefore, we suggest that with tailored educational interventions, diagnostic accuracy may be improved. Studies investigating simple training interventions, such as workshops, in non-specialist ED nursing staff have consistently demonstrated improved correlation between physician and nurse ordering, as well as more accurate test interpretation.[21-23] As such, further research is required which incorporates formal training in chest pain assessment for nursing staff, and focuses on the identification of low-risk patients who may be suitable for early discharge.

An important limitation to this study is that we included in this analysis only patients with suspected ACS, as decided by the treating physician. Therefore we can make no conclusions on the ability of nursing staff to identify those patients with suspected ACS from undifferentiated chest pain. Current evidence here is limited, with one small study suggesting that nursing staff have a sensitivity approaching 90% in identifying cardiac chest pain.[24] In order to avoid over-selection of patients for rapid rule-out protocols and

consequent adverse effects of resource use through unnecessary biomarker testing, this issue requires clarification.

A further limitation to this analysis is the difference in the proportion of patients who underwent assessment by physicians (95.0%) compared to those assessed by nursing staff (77.6%). This finding may be explained by the ethical necessity for nursing staff to provide written informed consent prior to study participation and the transient nature of the staff body during the recruitment period. However, this finding may cause unseen bias in the clinical characteristics of patient groups and may mean that the study had insufficient power to detect a diagnostic difference that did in fact exist (a Type II statistical error).

CONCLUSION

The diagnostic accuracy of ED nursing staff risk-assessment, using an established chest pain risk score is similar to that of ED physicians and inter-observer reliability between assessor groups is fair. When combining nursing risk-stratification with presentation high-sensitivity troponin testing, a nurse-led ADP would have a miss-rate of 1.1% for MACE at 30 days.

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Contributors

All authors meet the criteria for authorship as follows: EC: conception and design, analysis and interpretation of the data, drafting manuscript or critical revisions for intellectual content and final approval of the manuscript. AK and KG: conception and design, drafting manuscript or critical revisions for intellectual content and final approval of the manuscript.

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Competing Interests

EC has received funding from Abbott in support for related research. KG has received funding from AstraZeneca and Takeda UK for related research. AK has no competing interests.

Patient and nursing staff consent: Obtained

Ethics Approval: Frenchay Research Ethics Committee (reference 12/SW/0133).

Peer Review: Not commissioned; externally peer reviewed.

Data Sharing: All requests for further data from this study should be addressed to the corresponding author.

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Figure 1. Participant recruitment flow chart

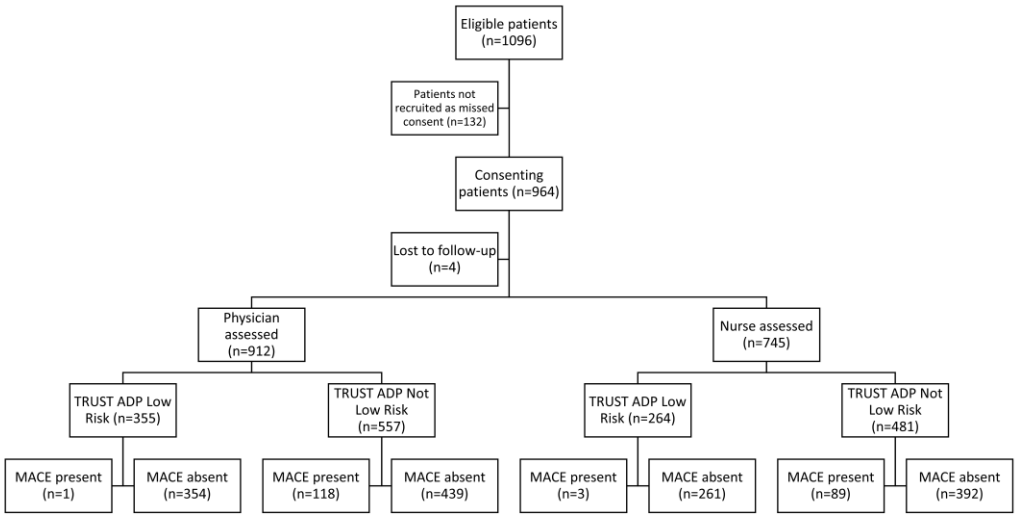
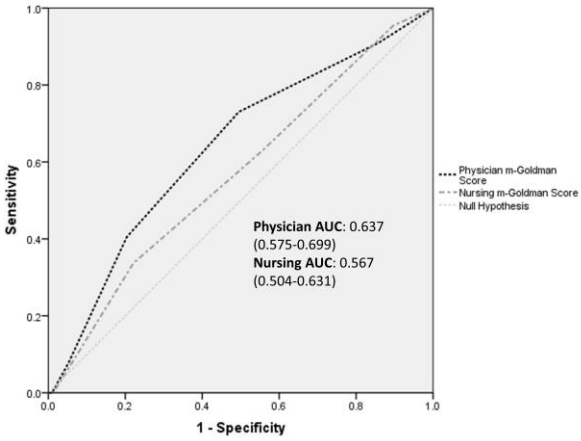
Figure 2. Receiver operating characteristic curves of the m-Goldman score according to assessor groups