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Accuracy of emergency medical services (EMS) telephone triage in identifying acute coronary syndrome (ACS) for chest pain patients: A systematic literature review

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D) Pre-hospital, Chest pain, telephone triage, ACS, Life-threatening conditions,
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Abstract;

Objective:

To systematically appraise the available evidence to determine the diagnostic accuracy of the EMS telephone triage for patients with chest pain suspected to be caused by ACS or life-threatening conditions.

Design:

Systematic review.

Data sources:

Electronic searches were performed in Embase, Medline, and Cinahl databases for relevant papers.

Eligible criteria:

The review included all types of original studies with adult patients (>18 years with a primary complaint of chest pain who called EMS for an ambulance and evaluated dispatch triage priority, and linked to final diagnosis of ACS, acute myocardial infarction (AMI), or other life-threatening conditions.

Data extraction and synthesis:

standardised data extraction form was used to extract and collect data as study design, population, study period, and outcome. Also, all data required were extracted for diagnostic accuracy assessment including 2x2 tables when available for dispatch priority and prediction models priority for suspected ACS, or life-threatening conditions. Two authors independently extracted the data. Risk of bias was assessed using (QUDAS-2) assessment tool.

Result:

In total, 553 studies were identified from the literature search and cross-referencing. After excluding 550 studies, three were eligible for inclusion. Among those 3 studies, there are different prediction models developed by authors with variation in variables used to detect ACS. The overall result showed that dispatch triage tools have good sensitivity to detect ACS and life-threatening conditions even though they are used to triage sign and symptoms rather than diagnosing the patients. On the other hand, prediction models were built to detect ACS and life-threatening conditions and therefore it showed better sensitivity and NPV.

Conclusion:

EMS dispatch systems accuracy for ACS and life-threatening conditions associated with chest pain is good. Since the dispatch tools were built to triage ambulance response priority based on sign and symptoms, this lead to over triage among non life-threatining chest pain patients. Over triage were slightly reduced by deriving different prediction models and showed better sensitivity.

Strength and limitations:

- Up to our knowledge, this is the first systematic review looking into the accuracy of pre-hospital chest pain telephone triage.
- It is possible that some relevant papers were missed because we only included studies that have adult participants who are >18 years old and we excluded papers not published in English language.
- Unfortunately, we couldn't conduct a meta-analysis as there was variations between dispatch system tools and priority types.
- Also, there was a difference in the definition of life-threatening conditions definition between included studies.

Abbreviations list:

ED: Emergency Department; ACS : Acute Coronary Syndrome; AMI: Acute Myocardial Infarction; ECG: Electrocardiogram; NPV: Negative Productive Value; QUADAS: Quality Assessment of Diagnostic Accuracy Studies; PPV: Positive Predictive Value; STEMI: ST-Elevation Myocardial Infarction; ACS: Acute Coronary Syndrome;

Keywords:

Pre-hospital, Chest pain, telephone triage, ACS

Background:

Chest pain, which is one of the main symptoms of ACS, is one of the most common reasons for ambulance callouts and presentations to EDs (1, 2). Patients with ACS typically present with chest pain. However, the majority patients with chest pain transported by ambulance are ultimately diagnosed with self-limiting, non-cardiac disease. Thus, chest pain leads to over-triage patients and increases ambulance resource consumption, and crowed EDs (2, 3).

Two EMS dispatch systems are currently used in the UK: the Advanced Medical Prioritizing Dispatching System (AMPDS), and the National Health Service (NHS 999) System (4). Both systems use computerized telephone triage software that identify life-threatening conditions by a series of questions at the beginning of the call. For patients with a primary complaint of chest pain, they also include a specific series of questions to identify ACS and triage the case using the patient's sign and symptoms (3, 5). However, systematic reviews have shown that the accuracy of medical triage systems are backed by a low level of evidence (6, 7). There is also insufficient data on the dispatch protocol efficiency (7, 8). There is no consensus on the definitions used in Criteria Based Dispatch (CBD), which is program used to patients by signs and symptoms, and AMPDS (9, 10). Also, there is no consensus on the accepted level for over-triage, under-triage for medical emergency dispatch (6, 9). Therefore, systematic over-triage for chest pain patients is used as safe method by dispatch system to avoid potential harm to patients. As a result, it caused an over use of EMS resources (6) and showed difference between clinical findings and dispatch priority (8, 9). Therefore, with the current clinical guidelines for emergency medical services (EMS), it is hard to rule in or rule out ACS by telephone-triage (11).

We aimed systematically to appraise the available evidence to determine the diagnostic accuracy of the EMS telephone triage for patients with chest pain suspected to be caused by ACS or life-threatening conditions.

Methods:

The systematic review was conducted in accordance with PRISMA guidelines and following Cochrane methodology for diagnostic test accuracy reviews (12). PRISMA checklist provided in supplementary appendix. This systematic review was pre-registered on the PROSPERO database (reference CRD42020171184)

Search strategy and eligibility criteria:

We searched the Embase, Medline, and Cinahl databases on 3/03/2020 for the terms "chest pain, telephone or dispatch, triage, ACS or AMI, life-threatening conditions, and EMS or prehospital". Retrospective and prospective cohort studies written in English and investigating EMS telephone triage for chest pain patients linked with final diagnosis of ACS, or life-threatening conditions were eligible.

Studies included:

Based on the inclusion criteria, titles and abstracts were independently screened and shortlisted by two reviewers (AbA and ChR). The inclusion criteria were: (1) the study included adult patients (>18 years); (2) the study included patients with a primary complaint of chest pain who called EMS for an ambulance; (3) the studied evaluated dispatch triage priority; (4) the study provided data for a linked final diagnosis of ACS, acute myocardial

infarction (AMI), or other life-threatening conditions. Two reviewers independently reviewed and screened potentially relevant full text papers to identify those fulfilling the inclusion criteria. Any discrepancies between the reviewers were resolved by a third reviewer (AhA).

Outcome measures:

The primary outcome was a diagnosis of ACS, including ST elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI) and unstable angina. AMI (incorporating both STEMI and NSTEMI) is defined according to the universal definition of AMI (13). Unstable Angina is defined as sudden prolonged chest pain at rest >20 minutes, new onset severe angina, or previous angina that is increasing in severity of pain, duration of pain, and/or frequency (14).

The secondary outcome was the diagnosis of a life-threatening condition associated with chest pain. Since there is no universal definition for life-threatening conditions associated with chest pain, we included all relevant data from the studies, regardless of the precise definition used for 'life-threatening conditions'.

Methodological quality assessment:

The quality assessment of eligible articles was independently assessed by two reviewers (AhA and AbA), using modified Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool to suit the purpose of this systematic review (15). Discrepancies between reviewers were solved by discussion.

Data extraction:

After selecting the eligible studies, two investigators (AhA and AbA) used a standardised data extraction form to extract and collect data as study design, population, study period, and outcome. Also, both investigators extracted all data required for diagnostic accuracy assessment including 2x2 tables when available for dispatch priority and prediction models priority for suspected ACS, or life-threatening conditions.

Statistical analysis:

In line with our protocol, we considered pooling sensitivities, specificities, negative and positive predictive values (NPV and PPV, respectively) by meta-analysis. However, after reviewing the final list of studies meeting inclusion criteria, the reviewers unanimously concluded that meta-analysis would have been inappropriate due to clear evidence of clinical heterogeneity between studies, and missing data. We therefore undertook a narrative synthesis of the existing evidence.

Results:

In total, our literature search identified 553 potentially relevant articles of which 26 articles were considered eligible for inclusion after titles and abstract screening. After independent full text review, 23 articles were excluded and 3 articles met the inclusion criteria for this review (Figure 1). Excluded studies with reason of exclusion is shown in the supplementary appendix. (16-18).

Study Characteristics and Quality Assessments:

General study characteristics are summarized in Table 1. Patient characteristics and study weaknesses are summarised in Table 2. The details of the prediction models identified, together with the test characteristics (including sensitivity, specificity, NPV, and PPV) for the diagnosis of ACS and life-threatening conditions are shown in Tables 3 and 4.

The modified QUADAS-2 methodological quality assessment tool was used to assess all eligible studies as shown in the supplementary appendix 2. A summary of the quality assessment for each eligible study is shown in Figure 2. Two out of the three studies were retrospective cohort studies and compared the dispatch triage for ambulance response priority to the prediction model (16, 17) and one was prospective cohort study that only testing prediction model accuracy (18). ACS was adjudicated by experts in only one study (18) while the other two studies used the hospital final diagnosis of ACS, AMI, or life-threatening conditions. All eligible studies utilized the appropriate ACS or AMI definitions at the time of conducting the study.

Summary of the existing evidence

Gellerstedt et al derived a prediction model to detect AMI and life-threatening conditions patients calling for an emergency ambulance with chest pain. They aimed to effectively triage calls to determine the appropriate level of response (capable of providing advanced life support vs only basic life support). The final model used eight variables (age, gender, strong pain, dyspnoea, cold sweat, nausea, vertigo, and syncope) to calculate the probability of AMI or a life-threatening condition. Setting an arbitrary cut-off, the authors found that the model had greater sensitivity than and similar specificity to the judgement of the call handlers, which could potentially improve triage. However, performance of the model was only evaluated in the derivation set, with no validation presented (16).

In 2006, the same group derived a new prediction model in another study. They aimed to determine whether a computer-based decision support system could have superior accuracy for identifying life threating conditions or ACS in patients who called for an emergency ambulance with chest pain. *Gellerstedt et al* collected data from patients who called 112 complaining of chest pain using ten questions related to ACS with yes or no answers (17). They derived two prediction models based on those answers. The first prediction model (full model) incorporated data from all ten questions that dispatchers had asked, including: age, gender, central chest pain, high intensity pain, pain duration between 15 minutes and 24 hours, aggravated pain when breathing or moving, abnormal breathing, cold sweat, diabetes or previous CVD, previous ACS, and belief that symptoms are heart-related. The authors also derived a 'limited model', which only included variables that had a significant association with the presence of ACS or a life-threatening condition on bivariate analysis. These included: gender, age, central chest pain, high intensity pain, previous ACS, and a high priority based on dispatcher judgement. There was no significant difference in performance between the full model and limited model. However, both the limited and full models had superior sensitivity to the priority assigned by dispatchers in practice, both for ACS (Table 3) and life-threatening conditions (Table 4), with similar specificity (17). The model was derived in 70% of the available cohort and validated in the remaining 30%. The authors state that performance was 'similar' in the validation set, although no further details were provided.

Reuter et al used backward logistic regression to derive two separate prediction models to detect ACS among men and women, respectively (18). The male prediction model to detect ACS consisted of 8 variables, which are: age, smoking, severe pain, permanent pain,

breathing non-related pain, retrosternal pain, radiating pain, and additional symptoms. The female prediction model to detect ACS consisted of four variables, which are: age >60 years, history of coronary artery disease, breathing non-related pain, and radiating pain.

The male prediction model had an area under the receiver operating characteristic curve (AUC) of 0.76 (95% CI 0.73 – 0.79) in the derivation set (70% of the sample, which was randomly selected), which was maintained at 0.76 (95% CI 0.73 – 0.80) in the internal validation set (30% of the cohort). However, while the female prediction model had a similar AUC in the derivation set (0.79, 95% CI 0.75 – 0.83), it had lower accuracy in the validation set (AUC 0.67, 95% CI 0.60 – 0.74). No data were presented to enable calculation of sensitivity, specificity, PPV or NPV, and the output of the model was not compared to standard care or clinical judgement.

Discussion:

In this systematic review, we have identified three studies that presented the derivation of clinical prediction models to enhance the telephone triage of patients calling for an emergency ambulance with chest pain. None of the models presented had sufficiently high sensitivity to avoid the need for ambulance dispatch. The model derived by Gellerstedt *et al* (2006) used an outdated definition of AMI (using creatine kinase-MB as the reference standard biomarker), meaning that the results could not be applied to modern clinical practice. The second model derived by Gellerstedt *et al* (2016) underwent internal validation, but full details that validation were not published. Finally, Reuter *et al* derived two prediction models (for men and women, respectively) but did not present sufficient data to compare their performance to standard care. The prediction model for females had a poor AUC (0.67)

on internal validation. We identified no prediction models that have undergone external validation.

It is an extremely challenging task for dispatchers to identify ACS over the telephone as there are so many different causes of chest pain (11, 19, 20), and there is very limited information available at the time of the initial phone call. It has previously been reported that only 1 out of 18 patients who request an ambulance for a complaint of chest pain has ACS(3). While a validated prediction model would have clear benefits, this systematic review has identified no validated tools that could be used in current practice.

It has also been reported that the AMPDS triage system is not an accurate tool for identifying ACS patients (3). Moreover, in Denmark, Criteria-based Danish index is used to triage emergency calls and it resulted in over triage for 51% of chest pain calls as they were discharged without specific diagnosis and AMI were only found in 11% of chest pain calls (2). Dispatch triage systems were constructed to prioritize patient's condition and ambulance response grade and it were not developed for diagnosis. Therefore, it important to highlight that the use of prediction models would enhance ACS detection by looking into different symptoms associated with ACS.

It is clear that chest pain is a main symptom of ACS (2, 11, 19, 21-23). However, previous studies have shown that some ACS patients has been given lower priority during triage due to not having chest pain (3, 24). Deakin *et al* found that 13% of patients who called for an ambulance with confirmed ACS presented with no chest pain A study was conducted in Australia by Linda *et al* (25) to identify the sex differences in symptoms related to MI reported to EMS dispatch agrees with Deakin *et al* (3) and our findings that chest pain alone

is not a solid predictor of MI. Among female patients who called for an ambulance and were finally diagnosed with MI only 54.4% presented with chest pain, while among male patients 68.7% had chest pain. As a result, priority 1 allocation for women was 67% and for men 81% (25). Also, several studies have identified differences of symptoms reported by ACS patients. Interestingly, as we found in this systematic review, symptoms of ACS differ between male and female patients (18, 19, 25). One of the studies included in the search developed two different prediction models for men and women. However, the female prediction model failed to stand up to internal validation and should not be implemented (18). The most common symptom with MI following chest pain is Shortness of Breath (SOB) which appeared in 28.3% women vs 25.8% men. In patients presenting with no chest pain, SOB was the most common symptom, occurring in 38% women vs 32% men. These findings agree with what we have found as two studies that nausea, SOB and cold sweat were the most common symptoms reported after chest pain (16, 17). Women with ACS are less likely to present with chest pain when compared to men. Therefore, these differences might lead to the fact that dispatch triage systems can't accurately detect ACS.

Future Research:

Future work should focus on deriving and validating for chest pain triage to increase the sensitivity and specificity for detecting ACS and life-threatening conditions. Prediction models have shown that it has more accuracy than dispatch system tools. Prediction models could help in reducing the over triage and increasing the accuracy of detecting ACS and other life-threatening conditions associated with chest pain which could eventually lead to reduce over-triage for non life-threatining conditions, and EDs crowding.

Patient and Public Involvement:

No Patient involved.

Funds:

The publication fee is funded by the cardiovascular department, University of Manchester, UK. No grant or award number.

Limitations:

It is possible that some relevant papers were missed because we only included studies that have adult participants who are >18 years old and we excluded papers not published in English language. Unfortunately, we couldn't conduct a meta-analysis as there was variations between dispatch system tools and priority types. Also, there was a difference in the definition of life-threatening conditions definition between included studies.

Conclusion:

EMS dispatch systems accuracy for ACS and life-threatening conditions associated with chest pain is good. Since the dispatch tools were built to triage ambulance response priority based on sign and symptoms, this led to over triage among non life-threatining chest pain patients. Over triage were slightly reduced by deriving different prediction models and showed better sensitivity.

Table 1: Characteristics of included studies.

Study ID	Year	Country	Study design	Sites	Study period
Gellerstedt, et al. (16)	2006	Municipality of Go¨teborg	Prospective cohort study	1	3 months
Reuter, et al. (18)	2019	France	Follow-up prospective cohort study	1	18 months May 2010-Nov 2011
Gellerstedt, et al. (17)	2016	Sweden	Retrospective cohort study	1	7 months 1 may 2009- 28 Feb 2010

Table 2: Study and patient characteristics of all studies included in the systematic review.

Study ID	N	Population	Triage criteria	Exclusion criteria	Target condition	Study weaknesses
Gellerstedt, et al. (16)	503	Patients who called for an ambulance and who were assessed by the dispatcher as having chest pain	Dispatcher judgement vs prediction model (derived in this cohort)	NA	AMI, Life-Threatening Conditions	Retrospective, no sample size calculation, small simple size, out of date AMI reference standard (based on creatine kinase-MB rather than cardiac troponin)
Reuter, et al. (18)	3727	Adult 18 old called for ambulance chest pain with final diagnosis.	Prediction model	Difficult communication, language barrier inability to speak with patient	ACS	Information bias, unclear how AMI was adjudicated.
Gellerstedt, et al. (17)	1942	Patients who called 112 for an emergency	Dispatcher judgement vs	Lost diagnosis, or follow up.	ACS , Life-Threatening Conditions	95% CIs for test characteristics were not

		ambulance with a complaint of chest pain	prediction model			presented. Only internal validation completed, and the full results of that validation were not presented

ACS: Acute Coronary Syndrome; AMI: Acute Myocardial Infraction; CI: Confidence Interval; NA: Not Available.

Table 3: Diagnostic accuracy of dispatch tools and prediction models for ACS.

ID	N	Triage criteria	Sensitivity %	Specificity %	NPV %	PPV %	TP %	FP %	FN %	TN %
Gellerstedt, et al. (16)	503	Dispatch system (standard care)	85.7%	26.9%	87.7	32.02	90	291	15	107
	503	Prediction model	92.4%	28.6%	93.4	25.5	97	284	8	114
Reuter, et al. (18)	3727	Male Prediction model	NA	NA	NA	NA	NA	NA	NA	NA
	1824	Female Prediction model	NA	NA	NA	NA	NA	NA	NA	NA
Gellerstedt, et al. (17)	1942	Dispatch system	82.6	39.9	94.3	15.9	194	1026	41	681
	1942	Full Prediction model	90.2	40.9	96.8	17.4	212	1008	23	699
	1942	Limited Prediction model	91.1	41.1	96.96	17.5	214	1006	22	701

Table 4: Diagnostic accuracy of dispatch tools and prediction models for life-threatening conditions.

ID	N	Triage criteria	Sensitivity %	Specificity %	NPV %	PPV %	TP %	FP %	FN %	TN %
Gellerstedt, et al. (16)	493	Dispatch system	80.9	37.5	64.1	47.3	178	198	42	75
	493	Prediction model	86.4	31.8	74.4	50.5	190	186	30	87
Gellerstedt, et al. (17)	1944	Dispatch system	76.5	39.8	89.9	19.5	238	983	73	650
	1944	Full Prediction model	88.4	42.1	95	22.5	275	946	36	687
	1944	Limited Prediction model	88.7	42.1	95.1	22.6	276	945	35	688

Figure 1: Flow diagram of study selection

Figure 2: QUADAS-2 assessment of eligible studies

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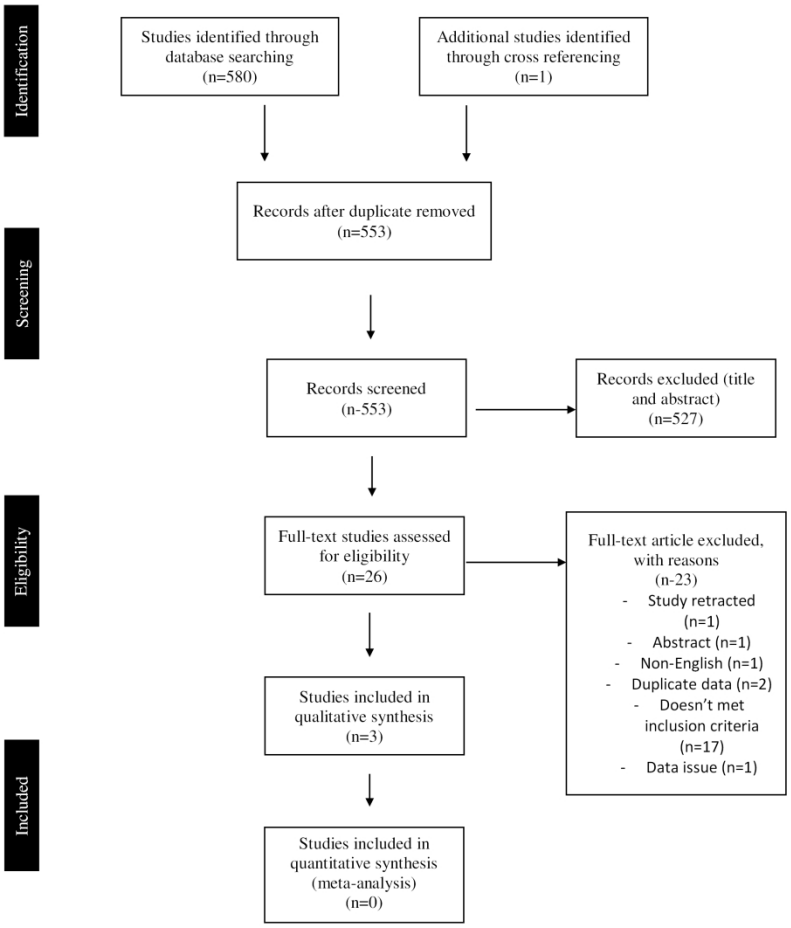

Figure 1: Flow diagram of study selection

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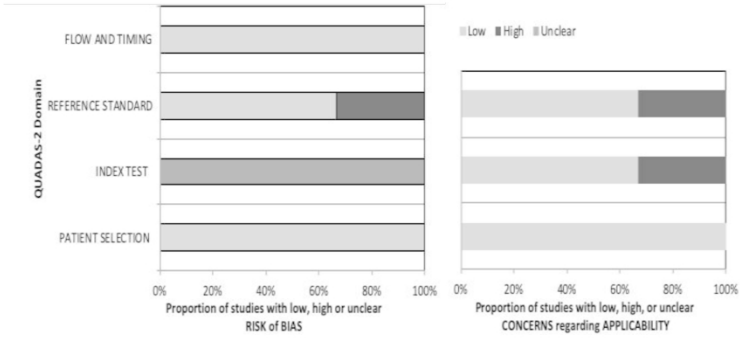

Figure 2: QUADAS-2 assessment of eligible studies

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Study	Reason for exclusion
(Deakin et al. 2006)	Included all medical (non-chest pain) calls as TN.
(Scott et al. 2017)	The authors didn't provide details on dispatch priority or sensitivity of triage accuracy.
(Herlitz et al. 2002)	Population Included based on any symptom that raise suspicion of AMI.
(Rawshani et al. 2017)	Duplicate data.
(Grzybowski et al. 2000)	No dispatch triage priority or sensitivity of triage accuracy.
(Plat et al. 2018)	Included all medical calls not only chest pain.
(Ball et al. 2016)	Included all medical and trauma calls.
(Sporer et al. 2008)	Included all patients transported by ambulance.
(Andersen et al. 2016)	included chronic diseases patients.
(Wouters et al. 2020)	Included patients called out of hours primary care not the emergency medical services.
(Rawshani et al. 2016)	Duplicate data.
(Sørensen et al. 2013)	Included patients based on ECG findings
(Thakore, McGugan, and Morrison 2002; Braunwald et al. 2002)	Included medical and trauma conditions.
(Higgins et al. 1993)	Included patients who arrived to ED only.
(Nehme, Andrew, and Smith 2016)	Measuring response time to time critical emergencies with no final diagnosis.
(Clawson et al. 2018)	Included AMI confirmed cases only and didn't provide non-cardiac chest pain to measure accuracy.
(Sporer and Wilson 2013)	Measured triage for accurately sending ALS or BLS team for drug administration.
(Adams et al. 2010)	No dispatch triage. Prioritizing patients based on ECG findings.
(Manzo-Silberman et al. 2015)	Calls collected from general practitioner and EMS dispatch with no linkage of priority to final diagnosis.
(Pedersen et al. 2019)	No dispatch priority assigned to the final diagnosis.
(Carmen Martín-Castro 2001)	Non-English.
(Pandey and Khandekar 2009)	Article retracted due to data issue.
(Bhargava et al. 2012)	Abstract.

Reference list:

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Supplementary Appendix

Customised QUADAS-2 tool for telephone triage in chest pain systematic review

Domain 1: Patient selection

A. Risk of bias

a. Was a consecutive or random sample of patients enrolled? Yes / No / Unclear

b. Did the study avoid inappropriate exclusions? Yes / No / Unclear

Could the selection of patients have introduced bias? Low / High / Unclear

B. Concerns regarding applicability

Is there concern that included patients do not match the review question? Low / High / Unclear

OVERALL:

LOW: Patients who call 999, 911, 112, 108 or another number for emergency medical attention with a primary complaint of chest pain

HIGH: Selection of a specific high- or low-risk population; setting is not an emergency telephone consultation; convenience sampling with clear potential for systematic selection bias

UNCLEAR: Insufficient information to determine the risk of bias.

Domain 2: Telephone triage intervention

A. Risk of bias

a. Was the outcome of telephone triage interpreted without knowledge of the outcome? Yes / No / Unclear

b. Is it unlikely that the telephone triage introduced biased risk group allocation? Yes / No / Unclear

Could the scoring or interpretation of the telephone triage have introduced bias? Low / High / Unclear

B. Concerns regarding applicability

Is there concern that the telephone triage, its conduct, or interpretation differ from the review question? Low / High / Unclear

OVERALL:

LOW: Telephone triage outcome calculated prospectively by treating clinicians, blinded to patient outcome.

HIGH: Telephone triage outcome calculated without blinding to outcome. Retrospective calculation of telephone triage outcome.

UNCLEAR: Insufficient information.

Domain 3: AMI/serious adverse event allocation

A. Risk of bias

a. Was the universal definition of AMI used to define the reference standard? Yes / No / Unclear

b. Was the reference standard adjudicated without knowledge of the telephone triage? Yes / No / Unclear

Could the reference standard, its conduct, or its interpretation have introduced bias? Low / High / Unclear

B. Concerns regarding applicability

Is there concern that the target condition as defined by the reference standard does not match the review question? Low / High / Unclear

OVERALL:

LOW: All patients underwent reference standard investigations for AMI including troponin sampling. The diagnosis of AMI was adjudicated by at least two investigators who were blinded to the telephone triage outcome. Serious adverse events include death (all cause), aortic dissection, pulmonary embolism and tension pneumothorax

HIGH: Outdated definition for AMI or definition inconsistent with the universal definition. The definition of serious adverse events does not include one of the core components specified above. Follow up procedure raises significant concerns about the possibility of missed events (e.g. chart review at a single centre without some assurance that this method would capture all relevant events).

UNCLEAR: Insufficient information.

Domain 4: Flow and timing

A. Risk of bias

a. Did all included patients receive an appropriate reference standard? Yes / No / Unclear
b. Did patients receive the same reference standard? Yes / No / Unclear
c. Follow-up procedure was sufficiently long to not miss relevant adverse events? Yes / No / Unclear
d. Did no significant loss to follow up/exclusion due to incomplete records occur? Yes / No / Unclear

Could the patient flow have introduced bias? Low / High / Unclear

LOW: All patients underwent reference standard investigations for AMI including troponin sampling. Patients were followed up through their subsequent inpatient course or for at least 7 days.

HIGH: Not all patients were subjected to appropriate reference standard investigations including troponin sampling.

UNCLEAR: Insufficient information. This option includes lack of detail about troponin testing and the follow up procedure.

Table 1: QUADAS-2 assessment of included studies (✓ Low Risk, green, ✗ High Risk, red, ? Unclear Risk, amber)

Study	RISK OF BIAS				APPLICABILITY CONCERNS			OVERALL		
	PATIENT SELECTION	TELEPHONE TRIAGE	AMI /SAE ALLOCATION	FLOW AND TIMING	PATIENT SELECTION	TELEPHONE TRIAGE	AMI /SAE ALLOCATION	PATIENT SELECTION	TELEPHONE TRIAGE	AMI /SAE ALLOCATION
1										
2										
3										
4										
5										
6										
7										

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	5-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	7
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6-7
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	7-8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	7,8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	7
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	8
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Table 1,2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	9
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	9
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	8-11
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Figure 2
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Tables 3,4
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	11-13
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	14
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	14

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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Accuracy of emergency medical services (EMS) telephone triage in identifying acute coronary syndrome (ACS) for chest pain patients: A systematic literature review

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Accuracy of emergency medical services (EMS) telephone triage in identifying acute coronary syndrome (ACS) for chest pain patients: A systematic literature review

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Abstract;

Objective:

To systematically appraise the available evidence to determine the accuracy of decision aids for Emergency Medical Services (EMS) telephone triage of patients with chest pain suspected to be caused by acute coronary syndrome (ACS) or life-threatening conditions.

Design:

Systematic review.

Data sources:

Electronic searches were performed in Embase 1974, Medline 1946, and Cinahl 1937 databases from 03/03/2020 to 04/03/2020.

Eligibility criteria:

The review included all types of original studies that included adult patients (>18 years) who called EMS with a primary complaint of chest pain and evaluated dispatch triage priority by telephone. Outcomes of interest were a final diagnosis of ACS, acute myocardial infarction (AMI), or other life-threatening conditions.

Data extraction and synthesis:

Two authors independently extracted data on study design, population, study period, outcome and all data for assessment of accuracy, including cross-tabulation of triage priority against the outcomes of interest. Risk of bias was assessed using the QUADAS-2 assessment tool.

Results:

Searches identified 553 papers, of which three were eligible for inclusion. Those reports described the evaluation of three different prediction models with variation in the variables

used to detect ACS. The overall results showed that dispatch triage tools have good sensitivity to detect ACS and life-threatening conditions, even though they are used to triage signs and symptoms rather than diagnosing the patients. On the other hand, prediction models were built to detect ACS and life-threatening conditions and therefore prediction models showed better sensitivity and Negative Predictive Value (NPV) than dispatch triage tools.

Conclusion:

We have identified three prediction models for telephone triage of patients with chest pain. While they have been found to have greater accuracy than standard EMS dispatch systems, prospective external validation is essential before clinical use is considered.

Strength and limitations:

- To our knowledge, this is the first systematic review looking into the accuracy of pre-hospital chest pain telephone triage.
- It is possible that some relevant papers were missed because researchers only included studies that have adult participants who are >18 years old and excluded papers not published in English language.
- Unfortunately, because of the paucity of data for each decision aid, the data were not suitable for meta-analysis.
- Also, there was a difference in the definition of life-threatening conditions definition between included studies.

Funding:

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Registration:

This systematic review was pre-registered on the International prospective register of systematic reviews (PROSPERO) database (reference CRD42020171184)

Abbreviations list:

ED: Emergency Department; ACS : Acute Coronary Syndrome; AMI: Acute Myocardial Infarction; ECG: Electrocardiogram; NPV: Negative Predictive Value; QUADAS: Quality Assessment of Diagnostic Accuracy Studies; PPV: Positive Predictive Value;

STEMI: ST-Elevation Myocardial Infarction; ACS: Acute Coronary Syndrome; EMS: Emergency Medical Services

Keywords:

Pre-hospital, Chest pain, telephone triage, Acute Coronary Syndrome.

Background:

Chest pain, which is one of the main symptoms of acute coronary syndromes (ACS), is one of the most common reasons for ambulance callouts and presentations to emergency departments (EDs) (1, 2). However, most patients with chest pain who are transported by ambulance are ultimately diagnosed with self-limiting, non-cardiac disease. Thus, patients with chest pain tend to be systematically over-triaged, increasing ambulance resource utilisation, and contributing to ED crowding (2, 3).

Two EMS dispatch systems are currently used in the UK: the Advanced Medical Prioritizing Dispatching System (AMPDS), and the National Health Service (NHS 999) System (4). Both systems use computerized telephone triage software that identify life-threatening conditions by a series of questions at the beginning of the call. For patients with a primary complaint of chest pain, they also include a specific series of questions to identify ACS and triage the case using the patient's sign and symptoms (3, 5). However, systematic reviews have shown that there is only a low level of evidence to support the use of current triage systems (6, 7). There is also insufficient data on the dispatch protocol efficiency (7, 8). There is no consensus on the definitions used in Criteria Based Dispatch (CBD), which is the program used to triage patients by signs and symptoms, and AMPDS (9, 10). Also, there is no consensus on the accepted level for over- or under-triage for medical emergency dispatch (6, 9). Therefore, systematic over-triage for chest pain patients is used by dispatch systems to avoid potential harm to patients. EMS resource utilisation is increased as a result (6), and there are important differences between patients clinical findings when examined and dispatch priority (8, 9). Therefore, with the current clinical guidelines for emergency medical services (EMS), it is hard to rule in or rule out ACS by telephone-triage (11).

We aimed systematically to appraise the available evidence to determine the accuracy of decision aids that have been used for EMS telephone triage of patients with chest pain suspected to be caused by ACS or life-threatening conditions.

Methods:

The systematic review was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and following Cochrane methodology for diagnostic test accuracy reviews (12). A completed PRISMA checklist is provided in supplementary appendix 1. This systematic review was pre-registered on the International prospective register of systematic reviews (PROSPERO) database (reference CRD42020171184)

Search strategy and eligibility criteria:

We searched the Embase 1974, Medline 1946, and Cinahl 1937 databases from 3/03/2020 to 04/03/2020 for the terms "chest pain, telephone or dispatch, triage, ACS or AMI, life-threatening conditions, and EMS or prehospital". Retrospective and prospective cohort studies written in English were eligible. Search strategy table is provided in supplementary appendix 2.

Studies included:

Based on the inclusion criteria, titles and abstracts were independently screened and shortlisted by two reviewers (AbA and ChR). The inclusion criteria were: (1) the study

included adult patients (>18 years); (2) the study included patients with a primary complaint of chest pain who called EMS for an ambulance; (3) the studied evaluated dispatch triage priority; (4) the study provided data for a linked final diagnosis of ACS, acute myocardial infarction (AMI), or other life-threatening conditions. Two reviewers independently reviewed and screened potentially relevant full text papers to identify those fulfilling the inclusion criteria. Any discrepancies between the reviewers were resolved by a third reviewer (AhA).

Outcome measures:

The primary outcome was a diagnosis of ACS upon hospital admission, including ST elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI) and unstable angina. AMI (incorporating both STEMI and NSTEMI) is defined according to the universal definition of AMI (13). Unstable Angina is defined as sudden prolonged chest pain at rest >20 minutes, new onset severe angina, or previous angina that is increasing in severity of pain, duration of pain, and/or frequency (14).

The secondary outcome was the diagnosis of a life-threatening condition associated with chest pain. Since there is no universal definition for life-threatening conditions associated with chest pain, we included all relevant data from the studies, regardless of the precise definition used for 'life-threatening conditions'.

Methodological quality assessment:

The quality assessment of eligible articles was independently assessed by two reviewers (AhA and AbA), using a modified Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool to suit the purpose of this systematic review (15). Discrepancies between reviewers were solved by discussion.

Data extraction:

After selecting the eligible studies, two investigators (AhA and AbA) used a standardised data extraction form to extract and collect data as study design, population, study period, and outcome. Also, both investigators extracted all data required for diagnostic accuracy assessment including 2x2 tables when available for dispatch priority and prediction models priority for suspected ACS, or life-threatening conditions.

Statistical analysis:

In line with our protocol, we considered pooling sensitivities, specificities, negative and positive predictive values (NPV and PPV, respectively) by meta-analysis. However, after reviewing the final list of studies meeting inclusion criteria, the reviewers unanimously concluded that meta-analysis would have been inappropriate due to clear evidence of clinical heterogeneity between studies, and missing data. We therefore undertook a narrative synthesis of the existing evidence.

Results:

In total, our literature search identified 553 potentially relevant articles of which 26 were considered potentially eligible for inclusion after screening titles and abstracts. Following independent full text review, 23 articles were excluded and 3 articles met the inclusion

criteria for this review (Figure 1). Excluded studies with reason of exclusion is shown in the supplementary appendix 3 (16-18).

Study Characteristics and Quality Assessments:

General study characteristics are summarized in Table 1. Patient characteristics and study weaknesses are summarised in Table 2. The number patients in each study with each component of the outcome measures studied is summarised in Supplementary appendix 4 Table 1. The details of the prediction models identified, together with the test characteristics (including sensitivity, specificity, NPV, and PPV) for the diagnosis of ACS and life-threatening conditions are shown in Tables 3, 4.

The modified QUADAS-2 methodological quality assessment tool was used to assess all eligible studies as shown in the supplementary appendix 5. A summary of the quality assessment for each eligible study is shown in Figure 2. Two out of the three studies were retrospective cohort studies and compared the dispatch triage for ambulance response priority to the prediction model (16, 17) and one was prospective cohort study that only testing prediction model accuracy (18). ACS was adjudicated by experts in only one study (18) while the other two studies used the hospital final diagnosis of ACS, AMI, or life-threatening conditions. All eligible studies utilized the appropriate ACS or AMI definitions at the time of conducting the study.

Summary of the existing evidence

Gellerstedt *et al* derived a prediction model to detect AMI and life-threatening conditions patients calling for an emergency ambulance with chest pain. They aimed to effectively triage calls to determine the appropriate level of response (capable of providing advanced life support vs only basic life support). The final model used eight variables (age, gender, strong pain, dyspnoea, cold sweat, nausea, vertigo, and syncope) to calculate the probability of AMI or a life-threatening condition. Setting an arbitrary cut-off, the authors found that the model had greater sensitivity than and similar specificity to the judgement of the call handlers, which could potentially improve triage. However, performance of the model was only evaluated in the derivation set, with no validation presented (16).

In 2016, the same group derived a new prediction model in another study. They aimed to determine whether a computer-based decision support system could have superior accuracy for identifying life threating conditions or ACS in patients who called for an emergency ambulance with chest pain. *Gellerstedt et al* collected data from patients who called 112 complaining of chest pain using ten questions related to ACS with yes or no answers (17). They derived two prediction models based on those answers. The first prediction model (full model) incorporated data from all ten questions that dispatchers had asked, including: age, gender, central chest pain, high intensity pain, pain duration between 15 minutes and 24 hours, aggravated pain when breathing or moving, abnormal breathing, cold sweat, diabetes or previous cardiovascular disease (CVD), previous ACS, and belief that symptoms are heart-related. The authors also derived a 'limited model', which only included variables that had a significant association with the presence of ACS or a life-threatening condition on bivariate analysis. These included: gender, age, central chest pain, high intensity pain, previous ACS, and a high priority based on dispatcher judgement. There was no significant difference in performance between the full model and limited model. However, both the limited and full

models had superior sensitivity to the priority assigned by dispatchers in practice, both for ACS (Table 3) and life-threatening conditions (Table 4), with similar specificity (17). The model was derived in 70% of the available cohort and validated in the remaining 30%. The authors state that performance was 'similar' in the validation set, although no further details were provided.

Reuter *et al* used backward logistic regression to derive two separate prediction models to detect ACS among men and women, respectively (18). The male prediction model to detect ACS consisted of 8 variables, which are: age, smoking, severe pain, permanent pain, breathing non-related pain, retrosternal pain, radiating pain, and additional symptoms. The female prediction model to detect ACS consisted of four variables, which are: age >60 years, history of coronary artery disease, breathing non-related pain, and radiating pain.

The male prediction model had an area under the receiver operating characteristic curve (AUC) of 0.76 (95% CI 0.73 – 0.79) in the derivation set (70% of the sample, which was randomly selected), which was maintained at 0.76 (95% CI 0.73 – 0.80) in the internal validation set (30% of the cohort). However, while the female prediction model had a similar AUC in the derivation set (0.79, 95% CI 0.75 – 0.83), it had lower accuracy in the validation set (AUC 0.67, 95% CI 0.60 – 0.74). No data were presented to enable calculation of sensitivity, specificity, PPV or NPV, and the output of the model was not compared to standard care or clinical judgement.

Discussion

In this systematic review, we have identified three studies that presented the derivation of clinical prediction models to enhance the telephone triage of patients calling for an emergency ambulance with chest pain. None of the models presented had sufficiently high sensitivity to avoid the need for ambulance dispatch. While two of the prediction models were shown to have greater accuracy than standard dispatch systems, unfortunately the current evidence does not support the use of these prediction models in practice without further validation. However, the evidence to date does suggest that clinical prediction models for this use case could feasibly improve upon the accuracy of triage offered by standard EMS dispatch systems.

The original model derived by Gellerstedt *et al* (2006) used a now outdated definition of AMI (using creatine kinase-MB as the reference standard biomarker), meaning that the results could not be applied to modern clinical practice without further validation. The second model derived by Gellerstedt *et al* (2016) underwent internal validation, but full details that validation were not published. Finally, Reuter *et al* derived two prediction models (for men and women, respectively) but did not present sufficient data to compare their performance to standard care. The AUC for the male prediction model was 0.76, showing good overall accuracy. The prediction model for females had a poor AUC (0.67) on internal validation. We identified no prediction models that have undergone external validation.

It is an extremely challenging task for dispatchers to identify ACS over the telephone as there are so many different causes of chest pain (11, 19, 20), and there is very limited information available at the time of the initial phone call. It has previously been reported that only 1 out of 18 patients who request an ambulance for a complaint of chest pain has ACS(3). While a

validated prediction model would have clear benefits, this systematic review has identified no validated tools that could be used in current practice.

It has also been reported that the AMPDS triage system is not an accurate tool for identifying ACS (3). Moreover, in Denmark, Criteria-based Danish index is used to triage emergency calls and it resulted in over-triage for 51% of chest pain calls as they were discharged without a specific diagnosis and AMI was only found in 11% of patients (2). Dispatch triage systems were constructed to prioritize the pre-hospital response based on a patient's condition. They were not intended to make diagnoses. Therefore, it important to highlight that the use of prediction models for telephone triage may not be expected to 'rule out' ACS but to identify patients who may safely receive a lower priority response, while correctly identifying the vast majority of those who require an urgent response.

It is clear that chest pain is a main symptom of ACS (2, 11, 19, 21-23). However, previous studies have shown that some ACS patients has been given lower priority during triage due to not having chest pain (3, 24). Deakin *et al* found that 13% of patients who called for an ambulance with confirmed ACS presented with no chest pain A study was conducted in Australia by Linda *et al* (25) to identify the sex differences in symptoms related to MI reported to EMS dispatch agrees with Deakin *et al* (3) and our findings that chest pain alone is not a solid predictor of MI. Among female patients who called for an ambulance and were finally diagnosed with MI only 54.4% presented with chest pain, while among male patients 68.7% had chest pain. As a result, priority 1 allocation for women was 67% and for men 81% (25). Also, several studies have identified differences of symptoms reported by ACS patients. Interestingly, as we found in this systematic review, symptoms of ACS differ between male and female patients (18, 19, 25). One of the studies included in the search developed two

different prediction models for men and women. However, the female prediction model failed to stand up to internal validation and should not be implemented (18). The most common symptom with MI following chest pain is Shortness of Breath (SOB) which appeared in 28.3% women vs 25.8% men. In patients presenting with no chest pain, SOB was the most common symptom, occurring in 38% women vs 32% men. These findings agree with what we have found as two studies that nausea, SOB and cold sweat were the most common symptoms reported after chest pain (16, 17). Women with ACS are less likely to present with chest pain when compared to men. This may explain the relative underperformance of the female prediction model derived by Reuter *et al*.

Future Research:

This systematic review has highlighted two potential areas for future research. First, the three prediction models identified may add value over existing telephone triage algorithms but this would require prospective external validation. Second, the existing evidence suggests that it is feasible to derive a prediction model to enhance telephone triage for patients with suspected ACS. The derivation and validation of a new, contemporary prediction model could reduce the systematic over-triage of patients in future, while ensuring that those with life-threatening conditions consistently receive an urgent response. However, given the risks of delayed responses (e.g. 'time is muscle for patients with STEMI), a higher sensitivity than has been observed in the studies identified is likely to be required.

Patient and Public Involvement:

No Patient involved.

Ethical approval:

Ethical approval is not required for this systematic review.

Limitations:

It is possible that some relevant papers were missed because we only included studies that have adult participants who are >18 years old and we excluded papers not published in English language. Unfortunately, we couldn't conduct a meta-analysis as there was variations between dispatch system tools and priority types. Also, there was a difference in the definition of life-threatening conditions definition between included studies.

Conclusion:

We have identified three clinical prediction models for telephone triage of patients with chest pain. While the models have been found to have greater accuracy than standard EMS dispatch systems, the level of evidence to support their use is currently low. Prospective external validation is therefore required. However, our findings do support the feasibility of deriving and validating clinical prediction models to reduce over-triage while ensuring urgent responses for those who need them most.

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Tables and Figures

Table 1: Characteristics of included studies.

Study ID	Year	Country	Study design	Sites	Study period
Gellerstedt, et al. (16)	2006	Sweden	Prospective cohort study	1	3 months
Reuter, et al. (18)	2019	France	Follow-up prospective cohort study	1	18 months May 2010-Nov 2011
Gellerstedt, et al. (17)	2016	Sweden	Retrospective cohort study	1	7 months 1 may 2009- 28 Feb 2010

Table 2: Study and patient characteristics of all studies included in the systematic review.

Study ID	N	Population	Triage criteria	Exclusion criteria	Target condition	Study weaknesses
Gellerstedt, et al. (16)	503	Patients who called for an ambulance and who were assessed by the dispatcher as having chest pain	Dispatcher judgement vs prediction model (derived in this cohort)	NA	AMI, Life-Threatening Conditions	Retrospective, no sample size calculation, small simple size, out of date AMI reference standard (based on creatine kinase-MB rather than cardiac troponin)
Reuter, et al. (18)	3727	Adult 18 old called for ambulance chest pain with final diagnosis.	Prediction model	Difficult communication, language barrier inability to speak with patient	ACS	Information bias, unclear how AMI was adjudicated.
Gellerstedt, et al. (17)	1942	Patients who called 112 for an emergency ambulance with a complaint of chest pain	Dispatcher judgement vs prediction model	Lost diagnosis, or follow up.	ACS , Life-Threatening Conditions	95% CIs for test characteristics were not presented. Only internal validation completed, and the full results of

						that validation were not presented

ACS: Acute Coronary Syndrome; AMI: Acute Myocardial Infraction; CI: Confidence Interval; NA: Not Available.

Table 3: Diagnostic accuracy of dispatch tools and prediction models for ACS.

ID	N	Triage criteria	Sensitivity %	Specificity %	NPV %	PPV %	TP	FP	FN	TN
Gellerstedt, et al. (16)	503	Dispatch system (standard care)	85.7%	26.9%	87.7	32.02	90	291	15	107
	503	Prediction model	92.4%	28.6%	93.4	25.5	97	284	8	114
Reuter, et al. (18)	2,363	Male Prediction model	NA	NA	NA	NA	NA	NA	NA	NA
	1,824	Female Prediction model	NA	NA	NA	NA	NA	NA	NA	NA
Gellerstedt, et al. (17)	1,942	Dispatch system	82.6	39.9	94.3	15.9	194	1026	41	681
		Full Prediction model	90.2	40.9	96.8	17.4	212	1008	23	699
		Limited Prediction model	91.1	41.1	96.96	17.5	214	1006	22	701

Abbreviations: NPV: Negative Predictive Value ; PPV: Positive Predictive Value ; TP: True Positive; FP: False Positive; FN: False Negative; TN: True Negative.

Table 4: Diagnostic accuracy of dispatch tools and prediction models for life-threatening conditions.

ID	N	Triage criteria	Sensitivity %	Specificity %	NPV %	PPV %	TP	FP	FN	TN
Gellerstedt, et al. (16)	493	Dispatch system	80.9	37.5	64.1	47.3	178	198	42	75
	493	Prediction model	86.4	31.8	74.4	50.5	190	186	30	87
Gellerstedt, et al. (17)	1944	Dispatch system	76.5	39.8	89.9	19.5	238	983	73	650
	1944	Full Prediction model	88.4	42.1	95	22.5	275	946	36	687
	1944	Limited Prediction model	88.7	42.1	95.1	22.6	276	945	35	688

Supplementary appendix:

Table 1: Number of patients with each individual outcome by study

Legends to figures:

Figure 1: Flow diagram of study selection

Figure 2: QUADAS-2 assessment of eligible studies. Green = low risk; yellow = unclear; red = high risk

A. Contributorship statement:

Ahmed Alotaibi: writing protocol, data search, data extraction, quality assessment, and writing.

Abdulrahman Alghamdi: data search, data extraction, quality assessment.

Charles Renard: data search, data extraction, quality assessment.

Richard Body: protocol planning, writing, proofreading.

B. competing interests:

The authors declare that they have **no** conflict of **interest**

C. Funding:

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D. Data sharing statement:

All the data included were obtained from published articles.

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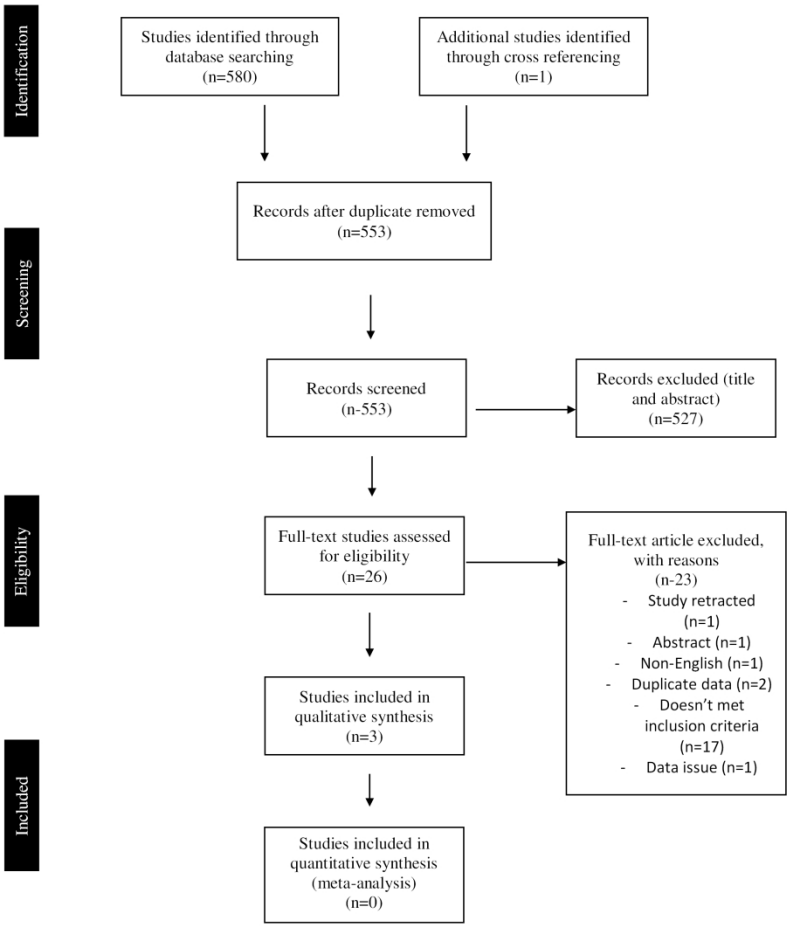

Figure 1: Flow diagram of study selection

209x297mm (300 x 300 DPI)

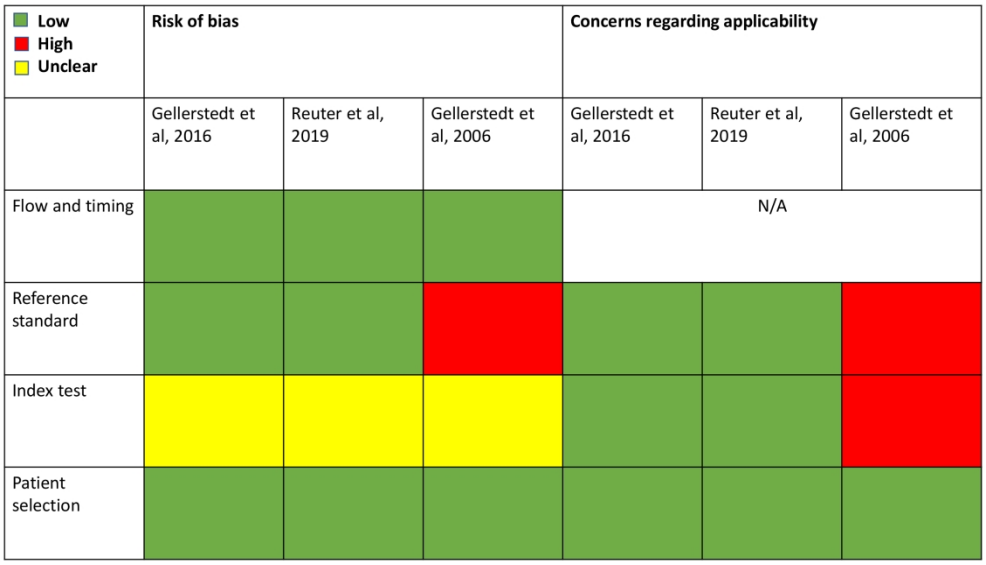

Figure 2: QUADAS-2 assessment of eligible studies.

338x190mm (200 x 200 DPI)

The PRISMA for Abstracts Checklist

TITLE	CHECKLIST ITEM	REPORTED ON PAGE #
1. Title:	Identify the report as a systematic review, meta-analysis, or both.	1
BACKGROUND		
2. Objectives:	The research question including components such as participants, interventions, comparators, and outcomes.	2 (objectives)
METHODS		
3. Eligibility criteria:	Study and report characteristics used as criteria for inclusion.	2 (eligibility criteria)
4. Information sources:	Key databases searched and search dates.	2 (data sources)
5. Risk of bias:	Methods of assessing risk of bias.	2 (data extraction & synthesis)
RESULTS		
6. Included studies:	Number and type of included studies and participants and relevant characteristics of studies.	3 (results)
7. Synthesis of results:	Results for main outcomes (benefits and harms), preferably indicating the number of studies and participants for each. If meta-analysis was done, include summary measures and confidence intervals.	3 (results)
8. Description of the effect:	Direction of the effect (i.e. which group is favoured) and size of the effect in terms meaningful to clinicians and patients.	N/A (no meta-analysis)
DISCUSSION		
9. Strengths and Limitations of evidence:	Brief summary of strengths and limitations of evidence (e.g. inconsistency, imprecision, indirectness, or risk of bias, other supporting or conflicting evidence)	3 (conclusions)

10. Interpretation:	General interpretation of the results and important implications	3 (conclusions)
OTHER		
11. Funding:	Primary source of funding for the review.	4 (funding)
12. Registration:	Registration number and registry name.	4 (registration)

Search Strategy

EMBASE database:
Date of Search: 03/03/2020
Final Result: 98 Articles.

Search Number	Keywords	Result
1	chest pain.mp. or exp thorax pain/	100365
2	dispatch.mp. or exp emergency medical dispatch/ or exp emergency health service/ or exp ambulance/	104949
3	telephone.mp. or exp telephone/	87404
4	phone.mp.	46215
5	exp heart infarction/ or myocardial infraction.mp. or exp acute heart infarction/ or exp adult/	8159567
6	3 or 4	127453
7	prehospital.mp.	16529
8	2 or 7	114149
9	1 and 5 and 6 and 8	98

MEDLINE database:
Date of search: 04/03/2020
Final result: 464

Search Number	Keywords	Result
1	chest pain.mp. or exp Chest Pain/	70473
2	acute coronary syndrome.mp. or exp Myocardial Infarction/ or exp Acute Coronary Syndrome/	189638
3	telephone.mp. or exp telephone/	64080
4	phone.mp.	21109
5	exp Emergency Medical Services/ or prehospital.mp.	139582
6	triage.mp. or exp Triage/	18912
7	emergency health services.mp. or Emergency Medical Services/	42024
8	3 or 4 or 6	91939
9	5 or 7	139622
10	1 and 2 and 8 and 9	464

Study	Reason for exclusion
(Deakin et al. 2006)	Included all medical (non-chest pain) calls as TN.
(Scott et al. 2017)	The authors didn't provide details on dispatch priority or sensitivity of triage accuracy.
(Herlitz et al. 2002)	Population Included based on any symptom that raise suspicion of AMI.
(Rawshani et al. 2017)	Duplicate data.
(Grzybowski et al. 2000)	No dispatch triage priority or sensitivity of triage accuracy.
(Plat et al. 2018)	Included all medical calls not only chest pain.
(Ball et al. 2016)	Included all medical and trauma calls.
(Sporer et al. 2008)	Included all patients transported by ambulance.
(Andersen et al. 2016)	included chronic diseases patients.
(Wouters et al. 2020)	Included patients called out of hours primary care not the emergency medical services.
(Rawshani et al. 2016)	Duplicate data.
(Sørensen et al. 2013)	Included patients based on ECG findings
(Thakore, McGugan, and Morrison 2002; Braunwald et al. 2002)	Included medical and trauma conditions.
(Higgins et al. 1993)	Included patients who arrived to ED only.
(Nehme, Andrew, and Smith 2016)	Measuring response time to time critical emergencies with no final diagnosis.
(Clawson et al. 2018)	Included AMI confirmed cases only and didn't provide non-cardiac chest pain to measure accuracy.
(Sporer and Wilson 2013)	Measured triage for accurately sending ALS or BLS team for drug administration.
(Adams et al. 2010)	No dispatch triage. Prioritizing patients based on ECG findings.
(Manzo-Silberman et al. 2015)	Calls collected from general practitioner and EMS dispatch with no linkage of priority to final diagnosis.
(Pedersen et al. 2019)	No dispatch priority assigned to the final diagnosis.
(Carmen Martín-Castro 2001)	Non-English.
(Pandey and Khandekar 2009)	Article retracted due to data issue.
(Bhargava et al. 2012)	Abstract.

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Supplementary appendix:

Table 1: Number of patients with each individual outcome by study

Study	Total number of participants	ACS (N) %	AMI (N) %	STEMI (N) %	NSTEMI (N) %	LTC (N) %
Gellerstedt, et al. (16)	503	NA	(105) 20.3%	NA	NA	(220) 43.7%
Reuter, et al. (18)	2363 Male	(508) 21.5%	NA	(215) 9.1%	(244) 10.3%	NA
	1824 Female	(139) 7.6%	NA	(46) 2.5%	(81) 4.4%	NA
Gellerstedt, et al. (17)	1942	(235) 12.1%	NA	NA	NA	NA
	1944	NA	NA	NA	NA	(311) 16%

Supplementary Appendix

Customised QUADAS-2 tool for telephone triage in chest pain systematic review

Domain 1: Patient selection

A. Risk of bias

a. Was a consecutive or random sample of patients enrolled? Yes / No / Unclear

b. Did the study avoid inappropriate exclusions? Yes / No / Unclear

Could the selection of patients have introduced bias? Low / High / Unclear

B. Concerns regarding applicability

Is there concern that included patients do not match the review question? Low / High / Unclear

OVERALL:

LOW: Patients who call 999, 911, 112, 108 or another number for emergency medical attention with a primary complaint of chest pain

HIGH: Selection of a specific high- or low-risk population; setting is not an emergency telephone consultation; convenience sampling with clear potential for systematic selection bias

UNCLEAR: Insufficient information to determine the risk of bias.

Domain 2: Telephone triage intervention

A. Risk of bias

a. Was the outcome of telephone triage interpreted without knowledge of the outcome? Yes / No / Unclear

b. Is it unlikely that the telephone triage introduced biased risk group allocation? Yes / No / Unclear

Could the scoring or interpretation of the telephone triage have introduced bias? Low / High / Unclear

B. Concerns regarding applicability

Is there concern that the telephone triage, its conduct, or interpretation differ from the review question? Low / High / Unclear

OVERALL:

LOW: Telephone triage outcome calculated prospectively by treating clinicians, blinded to patient outcome.

HIGH: Telephone triage outcome calculated without blinding to outcome. Retrospective calculation of telephone triage outcome.

UNCLEAR: Insufficient information.

Domain 3: AMI/serious adverse event allocation

A. Risk of bias

a. Was the universal definition of AMI used to define the reference standard? Yes / No / Unclear

b. Was the reference standard adjudicated without knowledge of the telephone triage? Yes / No / Unclear

Could the reference standard, its conduct, or its interpretation have introduced bias? Low / High / Unclear

B. Concerns regarding applicability

Is there concern that the target condition as defined by the reference standard does not match the review question? Low / High / Unclear

OVERALL:

LOW: All patients underwent reference standard investigations for AMI including troponin sampling. The diagnosis of AMI was adjudicated by at least two investigators who were blinded to the telephone triage outcome. Serious adverse events include death (all cause), aortic dissection, pulmonary embolism and tension pneumothorax

HIGH: Outdated definition for AMI or definition inconsistent with the universal definition. The definition of serious adverse events does not include one of the core components specified above. Follow up procedure raises significant concerns about the possibility of missed events (e.g. chart review at a single centre without some assurance that this method would capture all relevant events).

UNCLEAR: Insufficient information.

Domain 4: Flow and timing

A. Risk of bias

a. Did all included patients receive an appropriate reference standard? Yes / No / Unclear
b. Did patients receive the same reference standard? Yes / No / Unclear
c. Follow-up procedure was sufficiently long to not miss relevant adverse events? Yes / No / Unclear
d. Did no significant loss to follow up/exclusion due to incomplete records occur? Yes / No / Unclear

Could the patient flow have introduced bias? Low / High / Unclear

LOW: All patients underwent reference standard investigations for AMI including troponin sampling. Patients were followed up through their subsequent inpatient course or for at least 7 days.

HIGH: Not all patients were subjected to appropriate reference standard investigations including troponin sampling.

UNCLEAR: Insufficient information. This option includes lack of detail about troponin testing and the follow up procedure.

Table 1: QUADAS-2 assessment of included studies (✓ Low Risk, green, ✗ High Risk, red, ? Unclear Risk, amber)

Study	RISK OF BIAS				APPLICABILITY CONCERNS			OVERALL		
	PATIENT SELECTION	TELEPHONE TRIAGE	AMI /SAE ALLOCATION	FLOW AND TIMING	PATIENT SELECTION	TELEPHONE TRIAGE	AMI /SAE ALLOCATION	PATIENT SELECTION	TELEPHONE TRIAGE	AMI /SAE ALLOCATION
1										
2										
3										
4										
5										
6										
7										

The PRISMA for Abstracts Checklist

TITLE	CHECKLIST ITEM	REPORTED ON PAGE #
1. Title:	Identify the report as a systematic review, meta-analysis, or both.	1
BACKGROUND		
2. Objectives:	The research question including components such as participants, interventions, comparators, and outcomes.	2 (objectives)
METHODS		
3. Eligibility criteria:	Study and report characteristics used as criteria for inclusion.	2 (eligibility criteria)
4. Information sources:	Key databases searched and search dates.	2 (data sources)
5. Risk of bias:	Methods of assessing risk of bias.	2 (data extraction & synthesis)
RESULTS		
6. Included studies:	Number and type of included studies and participants and relevant characteristics of studies.	3 (results)
7. Synthesis of results:	Results for main outcomes (benefits and harms), preferably indicating the number of studies and participants for each. If meta-analysis was done, include summary measures and confidence intervals.	3 (results)
8. Description of the effect:	Direction of the effect (i.e. which group is favoured) and size of the effect in terms meaningful to clinicians and patients.	N/A (no meta-analysis)
DISCUSSION		
9. Strengths and Limitations of evidence:	Brief summary of strengths and limitations of evidence (e.g. inconsistency, imprecision, indirectness, or risk of bias, other supporting or conflicting evidence)	3 (conclusions)

10. Interpretation:	General interpretation of the results and important implications	3 (conclusions)
OTHER		
11. Funding:	Primary source of funding for the review.	4 (funding)
12. Registration:	Registration number and registry name.	4 (registration)