

REVIEW ARTICLE

Point-of-Care Tests' Role in Time Metrics of Urgent Interventions in Emergency Department; a Systematic Review of Literature

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Abstract: **Introduction:** Point-of-Care Testing (POCT) could be helpful in clinical decisions, treatment selection, monitoring, prognostication, operational decision-making, and resource utilization. This study aimed to review the role of POCT in time metrics of performing urgent interventions in the emergency department (ED) or disposition time to proper care. **Methods:** This was a systematic review of the literature based on the PRISMA statement. PubMed, Scopus, Web of Science, and EMBASE databases were searched for studies reporting the application of the POCT in the ED with outcomes of the time to intervention or disposition. **Results:** After reviewing 3708 articles, 16 studies with 100,224 participants were included in this systematic review. There were 5 randomized clinical trials (RCTs), 5 retrospective cohorts, 2 prospective cohorts, and 4 before-after studies. All studies were performed in an ED setting except for one study of prehospital EMS air medical transport. Different panels, ultrasound, cardiac parameters, echocardiography, and polymerase chain reaction (PCR) POCTs were used in the studies. Regarding the outcome measures, studies with many types of patients referring to ED used different indices of time to intervention or time to disposition. Studies on different shock circumstances used the time to the first bolus of hydration or vasopressor or intravenous antibiotics for septic shock patients and central venous catheterization (CVC) placement time in one study. Time to imaging was considered as the outcome in some studies. Overall, there was a high risk of bias, especially in case of the randomization methods, and non-blinded designs in RCTs. There was lower possibility of bias in non-randomized studies but the studies did not have enough follow-ups and in case of studies using advanced panels of POCT, results do not seem to be easily applicable to public health care in many countries. **Conclusion:** In synthesis of the evidence, all included studies were reporting the benefits of the POCT in decreasing the time to proper interventions and increasing the time to negative interventions in the last lines of critical care as well as the intubation and CVC placement.

Keywords: Emergency medicine; point-of-care systems; point-of-care testing; emergency treatment

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1. Introduction

Traditional public health systems are suffering from limited, delayed, and inefficient medical services, especially when confronted with crowdedness, disasters, and the aging population (1). In the face of ever-increasing public demand, emergency departments (EDs) face many challenges in maintaining consistent quality care (2, 3). Improved survival of critically ill patients in the emergency department is directly related to advances in early identification and treatment (4). Frequent overcrowding and extended waiting times strain emergency departments' capacity and compromise patient care. Until a few decades ago, the patient or his/her sample had to be sent to the laboratory, and it took hours or days for the results to reach the physician, and during this time, the patient's care had to continue without the information needed by the physician (5). Bedside tests are simple medical diagnostic tests that can be performed at the time and place of patient care. Their simplicity is due to the advancement in technology. In recent decades, more and more trials have been performed on Point-of-Care testing (POCT). POCT enables faster clinical decisions during diagnosis, treatment selection and monitoring, prognostication and operational decision-making, and resource utilization (6, 7). POCT has been shown to decrease the time to thrombolysis in stroke by as much as half an hour (8). Also, as its aim of creation was, POCT improves test turnaround times in emergency departments (9). Therefore, with regard to all of the above, the role of POCT can be considered to help cope with the stress of overcrowding of ED (10). While many review studies have been conducted on the efficacy of different commercially available POCTs in case of diagnostic accuracy of different medical conditions (11-13), and logically it should provide faster results and better test turnaround times, no previous study has evaluated its final effects on the time-critical patients of emergency department. Alter et al. evaluated the effect of applying POCT on the destination of the ED patients and drew a conclusion that these devices decreased the total length of hospital stay (14). But no in-hospital timing studies are provided in the literature. So, the aim of this study was to review the role of POCT in time metrics for performing urgent interventions in the ED or disposition time to proper care.

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2. Methods

2.1. Study design and setting

The present study is a systematic review that was carried out in accordance with the items mentioned in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (15).

A PICO model was used to structure the study question. Population of interest was patients referring to ED. Patients referring to ED are classified based on various triage models to address the urgency of the medical condition in literature. Siegfried et al. classified patients of ED into 3 groups; simple, complex, and critical (16). Simple group would receive only simple care and point-of-care tests along with only oral medications. Complex patients would undergo laboratory and imaging studies, receive intravenous medications, and remain under observation in ED or be admitted to a ward. Critical patients would be admitted to intensive care unit (ICU) from the ED and receive resuscitative care in ED, urgent cardiac interventions, gastrointestinal bleeding care, and other urgent surgeries or invasive diagnostic studies. Intervention/Exposure of interest was POCT application in ED. Comparison was done with the main standard of care test. Outcome was considered as time to critical care intervention. Critical care intervention included admission to ICU, cardiac interventions, urgent gastrointestinal (GI) interventions, and urgent surgeries.

2.2. Search strategy

A systematic electronic search in PubMed, Scopus, Web of Science and EMBASE databases using the keywords "emergency medicine", "point of care", "Point of care testing", "POCT", "rapid testing", "bedside testing", "emergency care" and all selected POCTs was done. A detailed search strategy of "(emergency medicine) OR (EMS) OR (emergency care) OR (Emergency Department) OR (Emergency Room) OR (ED) OR (pre-hospital)) AND ((Point of care testing) OR (POCT) OR (Bedside Testing) OR (lactate POCT) OR (rapid testing))" was conducted in PubMed. If there was a systematic review about POCT in the emergency setting, that study was also included in our review and the years after the search conducted in the included study were searched. This was used when the review focused on a single POCT item. The main text of the articles was also evaluated for additional references. In case of need for further data, contact with study authors to identify additional data was planned, which was not performed/needed. All searches were conducted from inception to August 2022.

2.3. Eligibility criteria

All observational or interventional clinical studies that were done in the emergency room and pre-hospital research envi-



ronment were included in the study, when applying POCTs in the treatment process of time-critical diseases. Only studies on non-trauma patients were considered, as the classification of the severity of the trauma cannot be merged with classifications of nontraumatic referrals of the ED due to the different pathways of management. Applying the ABCD rule in traumatic patients, most time-critical interventions should be performed in seconds to minutes; in addition, the airway management and laboratory data are less diagnostic and are mostly used for disease severity evaluation.

Studies were limited to adult populations to increase the homogeneity between studies to be able to synthesize the results. Studies conducted in various other departments in the hospital and at home or outside the hospital (except EMS) were not included in the study. Gray literature studies were not included as results that are not peer-reviewed might bias the final findings. Studies written in a language other than English were also excluded. Studies reporting accuracy and time to results of the test were not sought in this study as we were planning to evaluate the role of POCT in decreasing the test turnaround times.

2.4. Data collection

After removing the duplicates, the remaining studies were independently reviewed by two reviewers for eligibility to be included in the study. Any disagreement regarding study selection was resolved by consensus. The process of extracting data from included studies was done independently by two reviewers using the previously specified Excel form. The data extracted from each study included the name of the first author, the country, the number of subjects under investigation, the disease of the population under investigation, and the type of POCT test and the final result.

2.5. Quality assessment

The quality check was done using the appropriate checklist from The Scottish Intercollegiate Guidelines Network (SIGN) Methodology checklist and Risk of Bias 2 (RoB 2) tool checklist for RCTs (17). Two independent reviewers evaluated the studies based on the checklists and in case of non-agreement a third reviewer judged.

3. Results

After reviewing 3708 article titles and removing 1035 items due to duplication, 2673 article titles were examined. After removing 1007 unrelated titles, among the remaining 666 articles that were reviewed in terms of abstracts, 487 cases were removed due to irrelevance. The full texts of the 179 remaining articles were reviewed. Studies that met the inclusion criteria of this study were selected. Finally, 16 studies were included in this systematic review (18-33). Figure 1 shows

how the studies were selected. The baseline characteristics of these studies are shown in table 1.

There were 5 RCT studies (18, 21, 25, 28, 29), 5 retrospective cohorts (22, 23, 30, 32, 33), 2 prospective cohorts (24, 31), and 4 before-after studies (19, 20, 26, 27).

A total number of 100,224 participants were evaluated in these studies. All studies were conducted in the ED setting, except for one study of prehospital EMS air medical transport. Five studies used panels of POCT and 3 had evaluated POCT Ultrasound for diagnosis of pericardiocentesis and hemodynamic instability. Three studies evaluated lactate as the POCT for diagnosis of sepsis and critically ill circumstances. Cardiac parameters were used in 4 studies (20, 21, 26, 29). Renal function was assessed as POCT in 4 studies (25, 27, 28, 31) and POCT echocardiography was used in one study (23). We only found one study about the POCT Influenza PCR that had reported the outcome of time to intervention (24).

Regarding the outcome measures, studies with many types of patients referring to ED had used different indices of time to intervention or time to disposition. Studies on different shock circumstances had used time to first bolus of hydration or vasopressor or IV antibiotics for septic shock patients and central venous catheterization (CVC) placement time. Time to imaging was considered as the outcome in some studies on the POCT echocardiography. Although there were no comparisons to non-POCT, since it is not possible in the setting of the resuscitation, we included the study and outcome was the occurrence of intracardiac thrombus during cardiac arrest, which can be considered as the time of the end of resuscitation.

In synthesis of the evidence, all included studies were reporting the benefits of the POCT on decreasing the time to proper interventions and increasing the time to negative interventions in the last lines of critical care as well as intubation and CVC placement.

Overall, Time to intervention was not homogeneously reported in the literature but all POCT utilizations were associated with more rapid decision-making.

The possibility of adverse events or complications due to the unnecessary interventions in cases of false positive or negative results of the POCT remains the major problem in drawing the final conclusion in the review.

This raises the question whether samples should be sent for laboratory testing at the same time as performing the POCT or after a positive POCT.

3.1. Quality assessment

Risk of Bias 2 (RoB 2) tool checklist was used for 5 RCT studies (table 2). None of these RCTs were blinded. There was an overall high risk of bias, especially in case of the randomization methods, and non-blinded designs. The effects of



the false negative POCT care were not accurately addressed in the evaluated literature, increasing the possibility of non-investigated potential harms. SIGN checklist was used for other cohorts and before-after studies (table 3). Most studies' quality was compromised by some points. Diagnosis of most diseases is/was made based on clinical findings, imaging, and laboratory findings. In studies with mixed types of patients, study results might have been affected by the diagnosis based on other clinical findings, rather than the laboratory finding alone (bias of having an outcome in enrolment). Only Singer et al. b, Lau et al. (PREDICT Study), Perlitz et al., Deledda et al., and Hoch et al. had homogenous patients regarding the type of the disease.

4. Discussion

Many systematic review studies have focused on the advantages and disadvantages of using POCT in the emergency room. The belief that drives POCT is to make the test convenient and fast for the patient. These devices make it more likely that the patient, physician, and care team will receive results more quickly, thus allowing "clinical management" decisions to be made immediately. This assumption was assessed in our study. Various POCTs have been marketed: glucometers, blood gas and electrolyte analyzers, etc. POCTs are cheaper, faster, and smarter and, by making POCT more affordable, the tendency to use them for many diseases has increased (6, 7).

The accuracy of established diagnoses based on POCT was not taken into account in our investigation, but overall, outcomes of interest, i.e. times to the intervention, were not consistently reported by literature. However, all POCT utilizations were associated with a quicker decision-making process, which would be highly interesting to both health-care providers and policy-makers. The likelihood of adverse events or consequences from unneeded procedures when POCT findings are falsely positive or negative still poses a serious obstacle to making a definitive decision. This raises the question whether samples should be sent for laboratory testing at the same time as performing the POCT or following a positive POCT. This problem raises questions regarding the treatment's ultimate results, but it should be evaluated according to each patient's unique medical situation and the available POCT. These results were not comparable to any study as there was no study with similar objectives.

Major benefits are achieved when POCT device output is readily available to the care team in an electronic medical record (reduced turnaround time or TAT), and mortality is reduced when goal-directed therapy (GDT) is combined with POCT and use of electronic medical records. But our review has indicated the need for treatment confirmation as a factor limiting the application of POCT, especially in new POCTs.

Singer et al. (2015) provided the evidence that in time-critical patients with severe conditions, using the POCT of Hemoglobin (Hb), international normalized ratio (INR), troponin, and some other tests decreased the time to computed tomography (CT) with intravenous contrast injection, while their utilized POCT did not included any parameters needed for the estimation of the kidney function. But other studies that had evaluated renal function POCTs had not evaluated the time to CT scan metrics except for Bargnoux et al. (27). In addition, POCT has become established worldwide and plays a vital role in critical care. Best POCT known to the public is the blood sugar (BS) assessment tool. A review by Beik et al. evaluated the POCT in hyper/hypoglycemic state. Their results were supporting the application of the POC β -Hydroxybutyrate and BS tests in patients with suspected diabetes-related ketoacidosis (34).

Assessment of blood sugar is one of the vitals of the critical care, for which POCT has been routinely made available. But the application of the other new POCTs is also growing. Our review included many new POCT items, all of which satisfied the needs of the ED for quick disposition and decision-making for patients. We compared the care with and without the POCT in the ED setting. Some ongoing trials with good power were not included in our study due to being limited to the comparison framework; a trial of the LAPHUS was not included in our study as they had not compared POCT with non-POCT-based care (35, 36). One of the most common uses of POCT in ED is for patients with suspected sepsis, for whom timely intervention is of great importance. While we did not assess the safety issues, the systematic review of Kruse et al. only focused on the accuracy of lactate POCT in sepsis care and showed promising results (37). Morris et al. conducted the most similar review to our study. They included 8 studies about sepsis but only 2 of the studies had reported time to intervention indices (38). While our review showed positive results in decreasing the time to intervention of almost all evaluated interventions in different medical circumstances of POCT application, a study showed that accelerating the speed of the laboratory analysis in stroke care did not change door-to-needle time (39); yet, there were not using the bedside tests and only the laboratory works were speeded up.

Our review included many new POCT items, all of which satisfied the needs of the ED for quick disposition and decision-making for patients. This study revealed the methodological and conceptual limitations of the POCT literature in the time metric studies in the ED.

5. Limitations

Since there were multiple diverse reported outcomes based on utilizing different POCTs in diverse types of diseases, we



were not able to conduct any meta-analysis. Also, the quality of the included studies was not satisfactory and most studies suffered from significant methodological limitations that warrant the need for randomized trials or protocols for standard evaluation of the exposure and outcomes in the cohorts, for minimizing the risk of bias. Outcome level risk of bias assessment in this study is complex due to diverse outcomes. Most studies' quality was compromised by some points. Diagnosis of most diseases was made based on clinical findings, imaging, and laboratory findings. In studies with mixed types of patients, study results might have been affected by the diagnosis based on other clinical findings, rather than the laboratory finding alone (bias of having an outcome in enrollment). Only Singer et al., Lau et al. (PREDICT Study), Perlitz et al., Deledda et al., and Hoch et al. had homogenous patients regarding the type of the disease.

Although we used a comprehensive literature review, there might be some studies that were not found by our study due to incomplete retrieval of identified research or some studies might not have been published due to negative results or any other publishing issues, causing reporting bias.

6. Conclusion

In synthesis of the evidence, all included studies were reporting the benefits of POCT in decreasing the time to proper interventions and increasing the time to negative interventions in the last lines of critical care as well as the intubation and CVC placement.

7. Declarations

7.1. Acknowledgments

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7.2. Authors' contribution

SR and PA designed the study. SR, MSJ, SA, and RA wrote the protocol. HA, PA, BA, and FM conducted the literature review and data extraction. SAh, BRK, NK, and SR wrote the draft of the article. All authors contributed to revisions and confirmed the final version of the article.

7.3. Funding

None.

7.4. Conflict of interest

None.

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Table 1: The basic characteristics of included studies

ID	Design	Setting	N	POCT type	Patients	Comparison	Result of time to intervention
Mullen et al. (18)	RCT	pre hospital	59	Fingerstick lactate	Critically ill	POCT vs. No test	Higher time to central venous catheter (CVC) placement
Singer et al. A (19)	Before-after study	ED	160	Hand-held lactate POCT (i-STAT)	Sepsis suspected	POCT vs. Standard care	Lower time to IV fluids, ICU admissions; similar time to IV antibiotics
Singer et al. B (20)	Before-after study	ED	23 86	Panel of Hb and HCT, troponin I, BNP, lactate, and INR	Critical patients	POCT vs. Standard care	Lower time to contrast CT (only for Hb and HCT)
Goodacre et al. (21)	RCT	ED	22 43	CK-MB, myoglobin, troponin I [Siemens]	MI suspected	POCT vs. Standard care	Higher rate of cardiac intervention in first 24 hours
Hoch et al. (22)	Retrospective cohort	ED	25 7	Ultrasound	Pericardiocentesis	POCT vs. No test	Lower time to intervention
Lau et al. (PREDICT Study) (23)	Retrospective cohort	ED	56	Resuscitative echocardiography	Intracardiac Thrombus during cardiac arrest	POCT positive vs. Negative	Immediate termination of resuscitation
Perlitz et al. (24)	Cross-over design, prospective	ED	82 8	Influenza PCR	Influenza suspected	POCT vs. Standard care	Lower admission time to antiviral therapy
Lee et al. (25)	RCT	ED	23 23	Liver, renal, pancreas enzymes, and lipid panels, electrolytes, and blood gases	ED patients	POCT vs. Standard care	Lower time to intervention in almost all interventions
Deledda et al. (26)	Before-after study	ED	54,41 9	Cardiac troponin I	MI suspected	POCT vs. Standard care	Lower disposition time
Bagnoux et al. (27)	Before-after study	ED	17 8	Creatinine	Contrast-enhanced computed tomography scan	POCT vs. Standard care	Lower waiting time for imaging
Chaisirin et al. (28)	RCT	ED	26 0	Panel of metabolic, electrolyte, BUN, creatinine, CO2	ED patients	POCT vs. Standard care	Lower disposition time
Mogensen et al. (29)	RCT	ED	22 2	D-dimer, troponin i, CK-MB, CRP	ED patients	POCT vs. Standard care	Lower time to intervention only for acute bacterial infection (CRP)
Kankaanpää et al. (30)	Retrospective cohort	ED	17 59	Blood gases and chemistry panel, CBC, and CRP	Non-ambulatory ED patients	POCT vs. Standard care	Lower time to imaging
Jarvis et al. (31)	Prospective cohort	ED	25 70 9	Renal function analysis	ED patients	POCT vs. Standard care	Lower time to intervention
Mosier et al. (32)	Retrospective cohort	ED	5,4 41	Ultrasound	Hemodynamic instability	POCT before IV therapy or vasopressor vs. No POCT	No POCT group had the least time of intubation, followed by group of POCT after bolus water or vasopressor
Hall et al. (33)	Retrospective cohort	ED	38 34	Ultrasound	Shock	POCT vs. Standard care	Lower disposition time

POCT: Point-of-Care testing; RCT: randomized clinical trial; N: sample size; ED: emergency department; Hb: Hemohlobolin; INR: The international normalized ratio; CK-MB: Creatine Kinase MB; BUN: Blood Urea Nitrogen; CT: computed tomography; ICU: intensive care unit; IV: intravenous; PCR: polymerase chain reaction; HCT: hematocrit; MI: myocardial infarction; BNP: B-type natriuretic peptide; CRP: c-reactive protein; CBC: complete blood count.



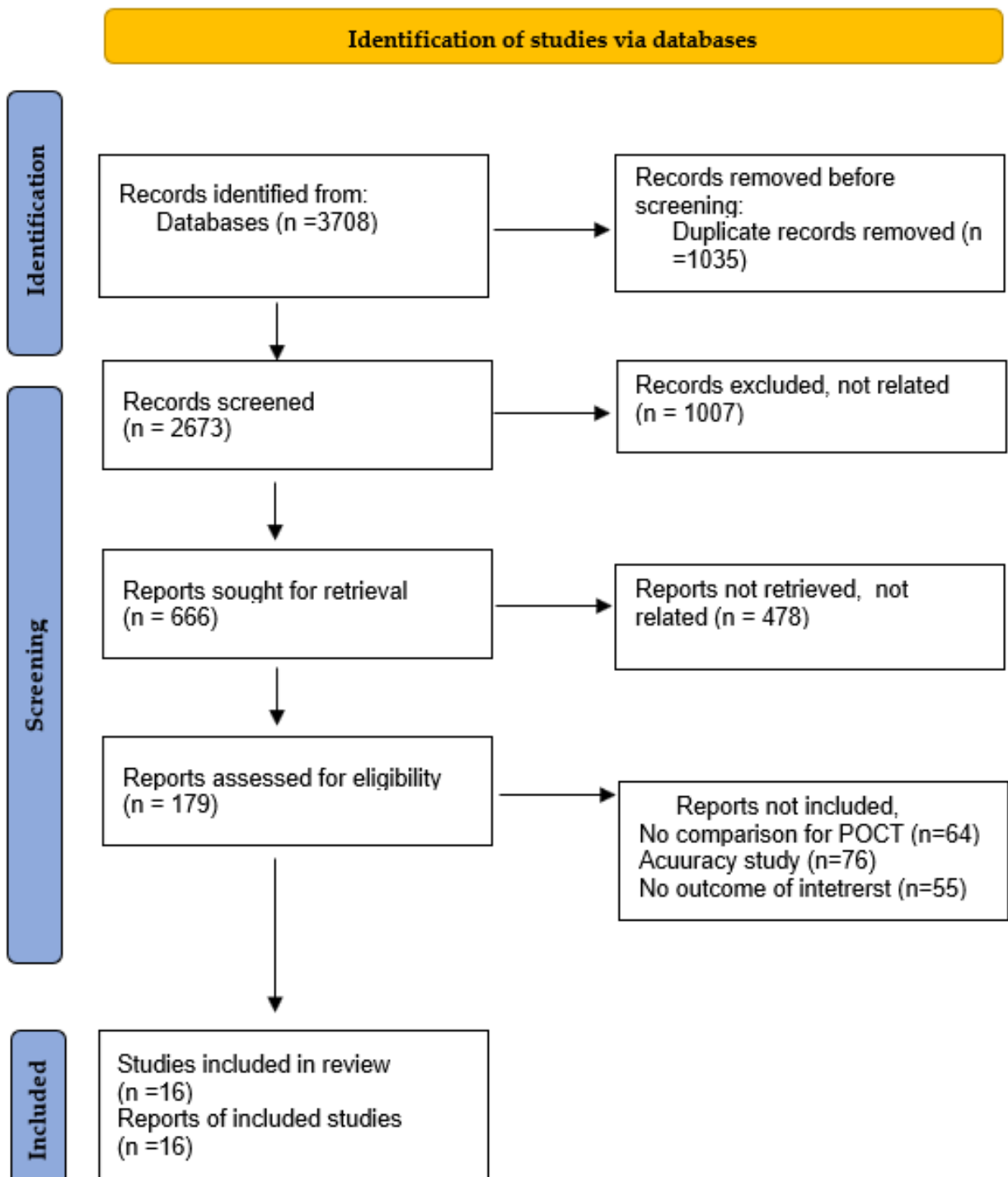


Figure 1: PRISMA flowchart of articles included in the review study. POCT: Point-of-Care testing.



Table 2: Critical appraisal of randomized clinical trials included in the review

Study	Randomization	Concealment	Imbalance Suggest Problem?	Risk of Bias
Mullen et al.	Probably no	No	Yes	High
Goodacre et al.	Yes	Yes	Yes	Low
Lee et al.	Yes	Probably no	Yes	Some concerns
Chaisirin et al.	Yes	Yes	Yes	Low
Mogensen et al.	Yes	Yes	Yes	Low

Table 3: Critical appraisal of cohort studies included in the review

Character	Singer et al.	Singer et al.	Singer et al.	Hoch et al.	Lau et al.	Perlitz et al.	Deledda et al.	Bargno-ux et al.	Kanka-anpää et al.	Jarvis et al.	Mosier et al.	Hall et al.
Clear question	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Comparable source populations	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bias of having outcome in enrolment	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Lost to follow-up reported and compared?	N	N	N	Y	N	N	N	N	N	N	N	N
Clear outcomes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Blinding	N	N	N	N	N	N	N	N	N	N	N	N
Knowledge of exposure status	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reliable exposure assessment	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Validity and reliability of assessment based on other sources	N	N	N	N	Y	N	N	N	N	N	N	N
Exposure repeated assessment	N	N	N	N	Y	N	N	N	N	N	N	N
Identified confounders	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Confidence intervals reported?	Y	N	Y	Y	Y	N	Y	N	Y	Y	Y	Y
Risk of bias?	**	*	0	0	0	**	0	**	**	**	0	0
Association between exposure and outcome?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Clinical application	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y

N: No; Y: Yes. Risk of bias has 3 levels of 0, *, **, where ** is showing the highest risk of bias and 0 for low source of bias.

