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Modification and empirical characterisation of the Lund Outcome Set for Evaluation of Triage

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Abstract

Background

Triage systems are used globally to prioritise patients in Emergency Departments (ED), yet no universally accepted standard exists that defines what patients should receive high priority. Each triage system has therefore been assessed in isolation using different methodologies. The Lund Outcome Set for Evaluation of Triage (LOSET), comprising 49 time-critical outcomes, was recently developed through expert consensus to address this knowledge gap, but requires systematic refinement and empirical characterization.

Objective

The aim of this study was to modify LOSET using definitions allowing it to be implementable using standard clinical data sources available across diverse healthcare systems.

Methods

We systematically modified LOSET from 49 to 36 outcomes by eliminating redundancies and ensuring implementability with standard coding practices. Implementation was tested using 624,909 ED visits in 2017 and 2018 at eight Swedish EDs. To examine whether the modified LOSET (mLOSET) outcomes captured genuine ED-level time-criticality, we assessed the association between mLOSET status and short-term death or ICU admission. We then characterized associations between mLOSET and commonly used triage outcomes including 7-day and 30-day mortality, hospital admission, and resource utilization using risk ratios.

Results

mLOSET excluding death/ICU admission strongly predicted death/ICU admission (risk ratio 34.2). mLOSET identified seven times more time-critical patients than death/ICU admission alone (54.7 versus 7.5 per 1,000 visits). mLOSET showed strong alignment with previously used outcomes: mLOSET-positive patients (defined as ≥ 1 mLOSET outcome) had a risk ratio of 40.4 for 7-day mortality, of 13.4 for 30-day mortality, of 3.8 for hospital admission, and 8-fold higher median costs. Diagnostic and intervention codes combined with laboratory values captured 93.5% of mLOSET-positive cases.

Conclusion

Systematic modification of the expert-derived LOSET yielded an implementable 36-outcome composite that captured time critical conditions using routinely available clinical data. The modified LOSET

demonstrated strong alignment with commonly used triage outcomes while markedly expanding case identification, supporting its clinical applicability for triage evaluation.

Introduction

Triage systems are used globally to identify time-critical conditions in emergency care systems, yet no universally accepted standard exists that defines which patients should receive high priority. Each triage system has therefore been assessed in isolation using mostly different methodologies and outcomes [1, 2].

In previous studies, four outcomes have been more common: Short-term mortality, Intensive Care Unit (ICU) admission, general ward admission and resource utilization[1]. However, each of these outcomes has fundamental limitations for triage evaluation. Death and ICU admission are unequivocal markers of severe time-critical conditions, but when used alone or together they fail to capture time-critical conditions where rapid intervention prevents deterioration[3]. This creates a methodological paradox, successful triage followed by effective treatment prevents deterioration, yet is classified as triage over-prioritisation. General ward admission lacks face validity as a time-criticality marker and there was a complete consensus against its use for triage validation in our previous study[3]. Resource utilization, popularized by Wuerz et al[4]. as a surrogate for time criticality, suffers from circular logic: Institutional protocols (e.g., all head injuries receive CT imaging) create triage patterns that reflect workflow rather than clinical appropriateness.

A composite approach is therefore necessary. The Lund Outcome Set for Evaluation of Triage (LOSET) was developed through expert consensus, using a modified Delphi approach, as a composite capturing time-criticality in a multi-dimensional way[3]. The present study aimed to modify LOSET for implementation using routinely available clinical data and to compare the modified LOSET with commonly used triage outcomes.

Methods

Study Design and Setting

We used data from the Skåne Emergency Medicine (SEM) cohort[5], which includes all adult patient visits to eight EDs in the Skåne region of southern Sweden during 2017 and 2018, including 624,909 ED visits from 325,385 unique patients.

The eight EDs range in size from approximately 5,000 to 80,000 annual visits and include both university hospitals and community hospitals. Five EDs operate 24 hours per day, seven days per week, while three provide care with limited opening hours e.g. 8.00–20.00[5]. All EDs serve adult patients. The SEM cohort integrates data from the Swedish National Patient Registry[6], laboratory information systems, regional electronic health records (Melior™, Siemens)[7], and the Swedish Cause of Death Register[8]. Episode

cost data were retrieved from the regional administrative system WebbPasis and included total reimbursement for the index visit, calculated using national diagnosis-related group (DRG) tariffs.[9]

We included all patient visits (age ≥ 18 years) presenting to any of the eight EDs during the cohort period. The study was approved by the Swedish Ethical Review Authority (Dnr 2019–05783). All analyses were performed using R version 4.5.1[10]. The unit of analysis was the individual ED visit.

LOSET Implementation

LOSET is a composite outcome developed through expert consensus using a modified Delphi approach with 18 Swedish triage experts. The LOSET development study produced 49 outcomes capturing time-critical conditions. The outcomes include serious diagnoses (e.g., anaphylaxis, bacterial meningitis, tension pneumothorax), critical interventions (e.g., percutaneous coronary intervention, surgical airway, thrombolysis), pathological laboratory values, ward movements such as intensive care admissions, and short-term mortality.

To identify LOSET outcomes in individual patients in the present study, we used diagnosis data coded with ICD-10 and Swedish clinical procedure codes (KVÅ)[11] from both the electronic health record system[7] and the Swedish National Patient Register[6], blood sample results from the laboratory information systems, intensive care unit admissions identified through ward transfer records, and mortality data from the Swedish Cause of Death Register.[8] A complete description of how each mLOSET outcome was implemented, including used timeframes and data sources, is provided in Supplementary materials.

Systematic modification of LOSET

Prior to implementation, we systematically modified LOSET to eliminate redundancies and improve implementability. We first removed outcomes that were captured in both the highest and second highest priority recommendation to reduce implementation complexity. With the same motivation we also consolidated outcomes where one was entirely captured by another more comprehensive criterion, merging outcomes representing the same clinical concept assessed through different measurement approaches, and removing outcomes that were operationally redundant with existing criteria. We then addressed implementability by separating compound outcomes requiring multiple data sources into distinct single-source outcomes and by removing outcomes with implementation barriers including absence from standard international coding systems, temporal-causal ambiguity where conditions may resolve before ED arrival, or requirements for complex multi-source data linkage with precise temporal sequencing that exceeded the complexity of other LOSET outcomes.

After completing all modification steps, we assessed the impact on case capture by determining how many criterion instances were removed and how many patients would no longer qualify as LOSET-positive (having at least one outcome) if removed outcomes had been their only qualifying criteria. We refer to this 36-outcome refinement as modified LOSET (mLOSET).

Implementation requirements

To assess mLOSET implementation with limited data availability, we determined what percentage of mLOSET-positive patients could be identified using each combination of data sources (diagnostic and procedure codes, laboratory values, ward transfers, medication records, and mortality data). For each mLOSET-positive patient, we determined which data sources would be required to identify their specific mLOSET outcomes. We then calculated what percentage of mLOSET-positive patients would be captured using each possible combination of data sources (31 combinations from 5 source types).

Analysis

Construct validation of mLOSET Capture Method

In the original LOSET study, outcomes were only considered valid if they occurred in, or arose from the ED. This is partially in conflict with standard diagnostic coding practice, where final diagnoses are registered upon discharge regardless of when the condition first manifested. A diagnosis in the discharge record might thereby reflect a condition that emerged after the ED presentation.

To validate that final discharge diagnoses captured genuinely time-critical ED conditions, we examined whether mLOSET outcomes identified short-term adverse outcomes known to reflect ED severity.[1]

For this purpose, we used ICU admission within 24 hours or death on the same or next date as ED arrival, as these represent unequivocal markers of severity established in prior triage validation research[1]. We calculated risk ratios comparing mLOSET-positive to mLOSET-negative patients (i.e., with no mLOSET outcome) using 99% confidence intervals using the delta method.[12] We analysed the extent to which 1. mLOSET without the short-term death outcome could predict short-term death, 2. mLOSET without the short-term ICU admission outcome could predict short-term ICU admission, and 3. mLOSET without both the short-term death and ICU admission outcomes could predict any of these outcomes.

These analyses were also conducted stratified by age groups (18–39, 40–59, 60–79, ≥ 80 years), sex, and ED census (small, medium, and large EDs based on annual patient volume). We also calculated individual risk ratios for each mLOSET outcome, comparing short-term death or ICU admission risk between patients with and without each specific outcome.

Comparison with commonly used triage outcomes

We compared mLOSET to other commonly used outcomes in triage assessment. We examined associations with 7-day mortality, 30-day mortality, and hospital admission by calculating risk ratios and stratifying by age group, sex, and ED census. We also analysed the relationship between mLOSET status and episode costs using DRG based cost data available from the cohort. Cost distributions were compared using median values due to expected non-normal distribution. We also tested the relationship between the number of mLOSET outcomes met (0 to 5+) and the same outcomes using risk ratios, using patients without any mLOSET outcomes as the baseline.

To quantify the clinical value of mLOSET beyond traditional death and ICU admission outcomes, we calculated the number of additional time-critical cases identified by mLOSET per 1,000 ED visits compared to using only short term death and ICU admission.

Results

Implementation and systematic modification of LOSET

The systematic modification reduced LOSET from 49 to 36 unique implementable outcomes.

Three outcomes appearing in both the highest and second-highest priority sets were consolidated (immediate surgical intervention, STEMI, and step-down unit admission). Four outcomes entirely captured by other outcomes were removed: intracerebral hemorrhage with ICU/intervention (already captured through existing ICU and surgery outcomes), anaphylaxis with adrenaline administration (captured by anaphylaxis diagnosis alone), and two sepsis outcomes stratified by NEWS2 score (captured by sepsis diagnosis alone). Two pairs of outcomes representing identical clinical concepts were merged: planned immediate surgery with immediate surgical intervention (both representing urgent operative need), and ICU admission with step-down unit admission into a single criterion, as step-down units were defined in the original LOSET study as providing ICU-level care. Massive transfusion, which presented zero cases in our cohort and is likely documented in operative rather than ED systems, was removed as operationally redundant with the acute surgery outcome.

Thrombolysis and thrombectomy, originally combined as a single outcome, were separated into two distinct outcomes to maintain single-source implementation and avoid requiring both diagnostic and intervention data simultaneously. Three outcomes were removed due to implementation barriers: tourniquet application was unimplementable in our cohort and absent from most international coding frameworks (found only in SNOMED CT among six major systems examined[10–15]). Glucose or glucagon administration for hypoglycemia presented temporal-causal ambiguity (if hypoglycemia was resolved before ED arrival, such as in an ambulance, the condition may no longer be time-critical at ED presentation) and required complex linking of laboratory values to medication administrations with precise temporal sequencing. Hemoglobin <60 mmol/L with ongoing bleeding required dual data sources and was thus removed.

Impact assessment showed that the two removed outcomes (excluding tourniquet which had no implementation pathway) were identified in 73 visits total, 60 for the glucose based outcome and 13 for the HB based one. However, 53 of these visits (72.6%) retained mLOSET-positive status through other concurrent outcomes, indicating that the refinement had negligible impact on overall case capture while substantially improving implementability. All remaining 36 refined outcomes were successfully implemented in the validation cohort. In the final dataset, there were 53,541 outcome instances across the cohort, and 34,219 patient visits were labeled mLOSET-positive.

While complete implementation of mLOSET requires five data types, healthcare systems with limited data availability can achieve 93.5% case capture if they have access to diagnostic/intervention codes and laboratory values (Figure 1). A detailed breakdown of case capture achievable with all possible combinations of data sources is provided in Supplementary Table 3, allowing implementation rate to be assessed based on available data infrastructure

Figure 1: Importance of data sources for implementing mLOSET showing accumulative capture of all mLOSET positive patients given an optimal implementation route, prioritizing diagnostic/procedure codes, Laboratory values, mortality, ward transfers and lastly medication records.

Association between mLOSET status and short-term severe outcomes

When evaluating whether our strategy of using final discharge diagnoses to capture mLOSET outcomes, we found strong associations between captured outcomes and short-term adverse outcomes. mLOSET outcomes excluding death predicted short-term death with a risk ratio (RR) of 26.8 (99% CI 24.1-29.8), mLOSET outcomes excluding ICU admission predicted ICU admission with a RR of 48.6 (99% CI 43.2-54.6), and mLOSET outcomes excluding both short term death and ICU admission had a RR of 34.2 (99% CI 31.6-36.9) for the combined outcome (Table 1).

These relationships remained consistent across demographic and institutional subgroups, with no stratified analysis showing non-significance (Supplementary Table 1). We also tested individual outcomes and found that 25/34 had a significantly increased risk ratio, with none having a significant protective effect (Supplementary Table 2).

Correlation between mLOSET and short term mortality, ICU Admission

		Short-term Death			ICU Admission			Short-term death or ICU		
	N total	N	Risk (%)	RR (99% CI)	N	Risk (%)	RR (99% CI)	N	Risk (%)	RR (99% CI)
All patients	624,909	2,428	0.16 / 4.39	26.8 (24.1-29.8)	2,453	0.11 / 5.36	48.6 (43.2-54.6)	4,712	0.28 / 9.44	34.2 (31.6-36.9)

mLOSET = modified Lund Outcome Set for Evaluation of Triage. Both Short term death and ICU Admission are part of mLOSET but removed here to assess whether capture strategy including final diagnosis captures in ED time criticality. For Risk columns the structure is WITHOUT/WITH mLOSET. Short-term death excludes short term death from mLOSET. ICU excludes ICU admission from mLOSET. ICU or Death excludes both. ICU = Intensive Care Unit, RR = Risk Ratio.

Table 1. Relationship between mLOSET and short-term adverse outcomes

Alignment of mLOSET with Commonly Used Triage Outcomes

When comparing mLOSET to other commonly used outcomes we found that mLOSET-positive had a risk ratio of 40.4 (99% CI 37.5-43.5) for 7-day mortality and 13.4 (99% CI 12.8-14.0) for 30-day mortality compared to mLOSET-negative patients. Hospital admission occurred in 80.2% of mLOSET-positive patients versus 21.2% of mLOSET-negative patients (RR 3.8, 99% CI 3.7-3.8). Median episode costs were 60,620 SEK for mLOSET-positive patients compared to 7,578 SEK for mLOSET-negative patients, representing an 8-fold difference. These associations remained consistent across sex and ED census with a reduction in risk ratio with increased age (Table 2).

mLOSET identified seven times more time-critical cases than death and ICU admission alone (54.7 versus 7.5 per 1,000 visits), substantially expanding case capture.

mLOSET compared to other common triage outcomes

		7-Day Mortality			30-Day Mortality			Hospital Admission			Cost
	N total	N 7 day mortality	Risk (%)	RR (99% CI)	N 30 day mortality	Risk (%)	RR (99% CI)	N admitted	Risk (%)	RR (99% CI)	Median Cost (SEK)
Overall											
All patients	624,909	5,424	0.27 / 11.11	40.4 (37.5-43.5)	13,163	1.26 / 16.80	13.4 (12.8-14.0)	152,828	21.23 / 80.19	3.8 (3.7-3.8)	7,578 /60,613
Sex											
Male	306,216	2,877	0.29 / 10.58	37.0 (33.3-41.1)	6,916	1.33 / 15.98	12.0 (11.3-12.8)	76,626	21.32 / 79.66	3.7 (3.7-3.8)	7,578 /61,554
Female	318,693	2,547	0.26 / 11.80	44.6 (40.1-49.7)	6,247	1.19 / 17.87	15.1 (14.1-16.0)	76,202	21.14 / 80.87	3.8 (3.8-3.9)	7,578 /59,474
Hospital Volume											
Small	53,999	392	0.30 / 9.73	32.4 (24.9-42.0)	1,121	1.42 / 15.89	11.2 (9.6-13.0)	11,600	18.96 / 74.83	3.9 (3.8-4.1)	5,833 /55,889
Medium	148,087	1,224	0.27 / 10.71	39.2 (33.5-45.8)	3,026	1.28 / 15.61	12.2 (11.1-13.3)	38,674	23.13 / 79.39	3.4 (3.4-3.5)	7,912 /50,526
Large	422,823	3,808	0.27 / 11.38	41.8 (38.2-45.8)	9,016	1.22 / 17.28	14.1 (13.4-14.9)	102,554	20.85 / 80.99	3.9 (3.8-3.9)	7,578 /64,654
Age Group											
18-39	185,778	126	0.01 / 2.97	415.2 (195.5-881.7)	180	0.03 / 3.46	131.3 (85.3-202.3)	18,308	8.81 / 59.87	6.8 (6.5-7.1)	5,271 /25,873
40-59	154,081	318	0.03 / 5.18	154.4 (104.0-229.1)	625	0.18 / 7.04	40.2 (32.7-49.3)	24,896	14.13 / 74.69	5.3 (5.1-5.4)	6,657 /55,683
60-79	187,547	1,915	0.29 / 9.63	33.0 (28.9-37.7)	4,729	1.47 / 14.95	10.2 (9.5-10.9)	61,387	28.44 / 83.37	2.9 (2.9-3.0)	8,469 /69,170
80+	97,503	3,065	1.22 / 18.98	15.6 (14.2-17.1)	7,629	5.26 / 28.92	5.5 (5.2-5.8)	48,237	45.05 / 85.78	1.9 (1.9-1.9)	16,071 /62,192

For Risk columns and Median Cost the structure is Value WITHOUT/WITH mLOSET; mLOSET = modified Lund Outcome Set for Evaluation of Triage; SEK = Swedish Krona.

Table 2. Association between mLOSET and commonly used triage validation outcomes

To examine whether the number of mLOSET outcomes met reflected increasing case severity, we analyzed the relationship between mLOSET outcome count and commonly used triage outcomes. Seven-day mortality increased from 0.3% in mLOSET-negative patients to 46.3% in those with five or more mLOSET outcomes. Thirty-day mortality showed a similar gradient (1.3% to 54.8%). Hospital admission increased from 21.2% in patients with zero outcomes to 77-88% in those meeting any mLOSET outcome. Median costs generally increased with the number of outcomes met, ranging from 7,578 SEK with zero outcomes to 163,096 SEK with five or more.

Relationship between mLOSET outcome count and previously used outcomes								
		7-Day Mortality		30-Day Mortality		Hospital Admission		Cost
Criteria Group	N Total	Risk (%)	RR (99% CI)	Risk (%)	RR (99% CI)	Risk (%)	RR (99% CI)	Median Cost (SEK)
0	590,691	0.27	-	1.26	-	21.23	-	7,578
1	22,955	7.03	25.6 (23.4-28.0)	12.57	10.0 (9.5-10.6)	77.24	3.6 (3.6-3.7)	52,108
2	6,638	11.06	40.2 (36.0-44.9)	16.50	13.1 (12.2-14.2)	87.84	4.1 (4.1-4.2)	71,127
3	2,615	21.95	79.8 (71.2-89.5)	27.92	22.2 (20.4-24.2)	87.04	4.1 (4.0-4.2)	111,713
4	1,271	42.17	153.4 (138.0-170.5)	49.72	39.6 (36.6-42.8)	77.42	3.6 (3.5-3.8)	102,562
5+	739	46.28	168.3 (149.2-189.9)	54.80	43.7 (39.9-47.8)	83.36	3.9 (3.8-4.1)	163,096

Table 3. Relationship between number of mLOSET outcome and commonly used triage validation outcomes

Discussion

This study modified the expert-derived LOSET from 49 to 36 implementable outcomes and assessed whether outcomes retrieved from routinely available diagnostic and intervention codes identified genuinely time-critical ED presentations. The strong association between mLOSET outcomes (excluding death and ICU admission) and short term death/ICU admission (RR 34.2) indicates that mLOSET reflects pathophysiology that drives early adverse outcomes. While it is likely that some captured diagnoses represent post ED-acquired conditions, the consistency across 25 of the individual outcomes, with none showing protective effects, indicates that it is reliable to use discharge diagnoses for the identification of mLOSET-positive cases.

mLOSET showed strong alignment with outcomes previously used for triage validation.[1] The risk ratios for 7-day mortality (40.4) and 30-day mortality (13.4) demonstrate that mLOSET identifies patients at substantially elevated mortality risk. The strong association between mLOSET positivity and short-term mortality is clinically meaningful, indicating that mLOSET-positive patients represent a high-risk group in whom early identification and prioritisation are warranted. Resource utilization showed similar patterns: mLOSET-positive patients had an 8-fold higher median costs and markedly higher admission rates (82% versus 21%).

By releasing standardized diagnostic definitions for each outcome (Supplementary Table 2), we enable future studies to implement mLOSET consistently[13]. Our demonstration that 93.5% of cases can be captured using only diagnostic codes and laboratory values addresses practical data availability constraints.

We argue that triage validation should identify whether rapid assessment was warranted based on exceeding an acuity threshold. From this perspective, mLOSET's diverse outcomes represent different clinical presentations that exceed this threshold rather than a mixture of unrelated endpoints[13–15]. This is strengthened by the finding that 25 of 34 individual mLOSET outcomes independently predicted death or ICU admission, with none showing protective effects.

This interpretation also resolves the prevention paradox described in the introduction. If only death or ICU admission defines time-criticality, successful triage followed by effective treatment appears to be over-prioritization. Hospital admission[1] and resource utilization[4], while associated with time-criticality, are surrogates that do not necessarily reflect it. mLOSET defines time-criticality through the underlying clinical condition rather than these indirect measures, correctly classifying prevented deterioration as appropriate triage.

Limitations

In this retrospective study we used data from a single Swedish region, which may limit generalizability to other patient populations. However, we believe that the data types we used are generally accessible for research in the western world. Similarly, mLOSET was developed through Swedish expert consensus, but the included diagnoses and interventions represent universally recognized time-critical conditions. Electronic health record data may contain coding errors, and as mentioned, the final diagnoses used to identify mLOSET outcome may not always have reflected the patient's condition at the ED. While some of the used timeframes for mLOSET differed from the original Delphi recommendations (e.g., death same or next date vs. in-ED death), these were selected to match data availability across major cohort studies [5, 17–23], improving real-world implementability of the mLOSET outcomes.

Conclusions

This study systematically modified LOSET to 36 implementable outcomes, eliminating redundancies and dual-source requirements. The 36 outcomes demonstrated strong alignment with all previously used triage validation measures, substantially expanding case identification (7-fold versus only death/ICU) while avoiding the circular logic of resource-based definitions. Importantly, mLOSET achieves this alignment by identifying the time-critical conditions themselves rather than relying on proxy outcomes like resource use or admission, which are inevitably contaminated by institutional protocols and workflow patterns more or less unrelated to ED clinical acuity. We believe that our clear definition of mLOSET enables future research to implement this outcome set consistently. Future implementation in settings with different diagnostic/intervention code frameworks should try to align with the present implementation.

Declarations

Informed consent was waived by the Swedish Ethical Review Authority (Dnr 2019-05783), as this study used existing de-identified registry data and did not involve direct participant contact.

Ethics approval and consent to participate

The study was approved by the Swedish Ethical Review Authority (Dnr 2019–05783).

Consent for publication

Not applicable. This study used de-identified registry data.

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Author Contribution

A.J. conceptualized the study, developed the methodology, performed formal analysis, and wrote the original draft. U.E. provided resources through data access and supervised the project together with A.E. and J.L.F., all contributing to manuscript review and editing.

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Writing assistance was provided by LLM, specifically Claude Sonnet 4 through Claude Sonnet 4.5 (Anthropic) for text editing and code generation. All content generated underwent multiple iterations of human review and improvement post generation.

Data Availability

The patient data used in this study are available from the authors upon reasonable request but restrictions apply for patient confidentiality reasons. The code used for analysis is supplied as supplementary material.

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Figures

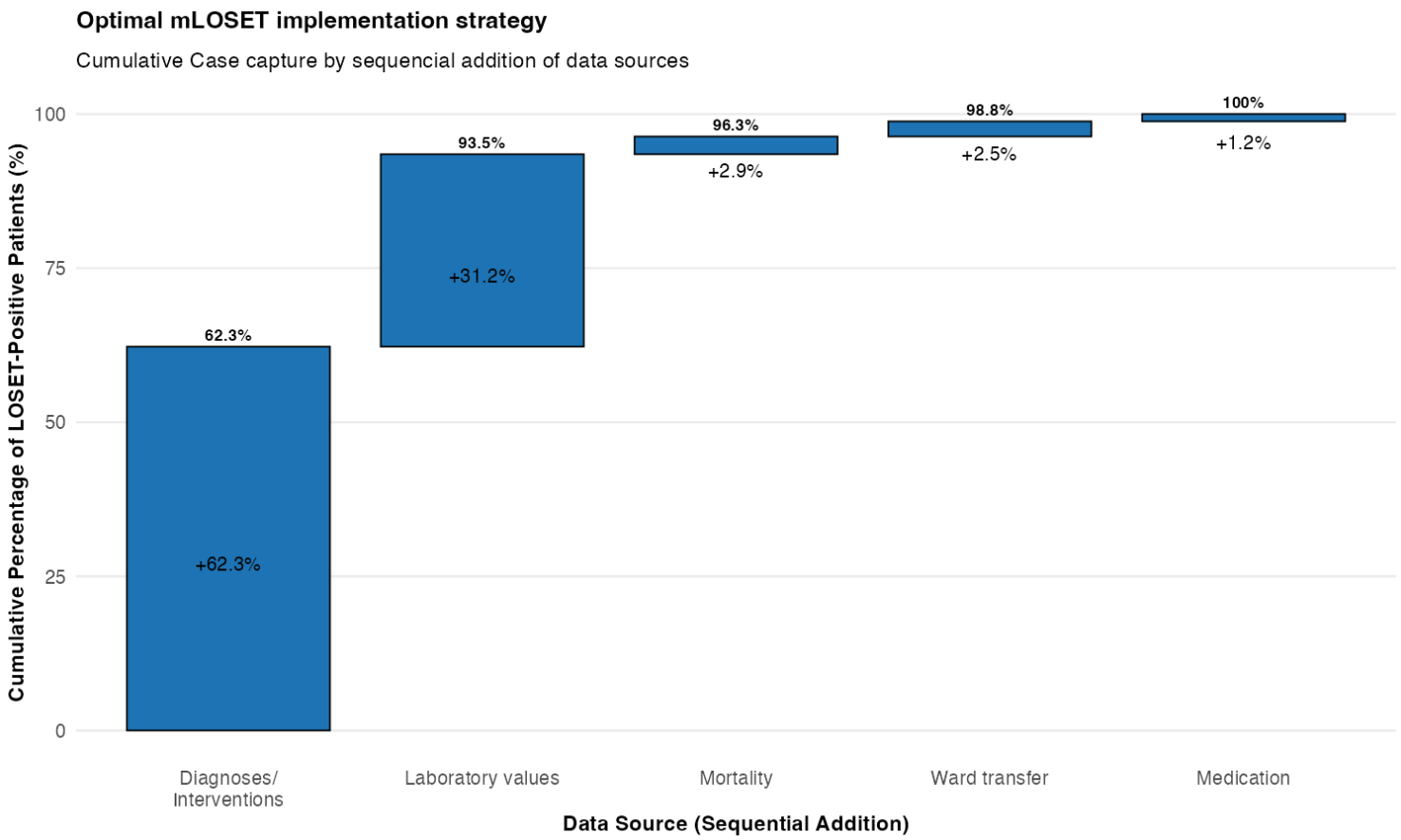


Figure 1

Importance of data sources for implementing mLOSET showing accumulative capture of all mLOSET positive patients given an optimal implementation route, prioritizing diagnostic/procedure codes, Laboratory values, mortality, ward transfers and lastly medication records.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SIModificationofLOSETSJTREM.docx
- losetvalidationv4.rmd