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Optimizing diagnostic testing processes to improve emergency department throughput: a systematic review

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Introduction: Emergency Department (ED) crowding is an intensifying crisis. While input, throughput, and output factors all contribute to crowding, throughput factors are the most dependent on ED staff and process. Diagnostic testing is a fundamental ED process that has not been systematically evaluated. We present a systematic review of interventions designed to reduce ED length of stay (LOS) by optimizing laboratory or imaging turnaround time, or by introducing point-of-care testing (POCT). **Methods:** We conducted systematic database searches in Medline, Embase, CINAHL, and the Cochrane Central Register of Controlled Trials without filters or language restrictions, of all interventions on diagnostic technology that affected ED throughput (PROSPERO:CRD42019125651). Studies were screened by two independent reviewers. Study quality was assessed using the Cochrane ROB-2 tools for randomized controlled trials (RCTs), and the National Heart, Lung, and Blood Institute tool for all other study designs. **Results:** 18 studies met inclusion criteria (Cohen's kappa = 0.69). Study results were not pooled due to high statistical heterogeneity as assessed by chi-squared and I-squared statistics. 12 POCT intervention studies reported LOS changes ranging from -114 to + 8 minutes (-26.8% to + 3.8%), although three were non-significant findings. Four studies that initiated POCT or lab-ordering at triage reported LOS reductions ranging from 22 to 174 minutes, but only one of these, at 29 minutes (16%), was statistically significant. One study of improved laboratory troponin processing reported a LOS reduction of 43 minutes (12.3%). Another, which allowed triage nurses to order ankle x-rays using the Ottawa ankle rules, reported a non-significant LOS reduction of 28 minutes for patients with ankle injuries. LOS improvements reflected the population of patients who underwent the testing modality, rather than overall ED LOS. Seven studies had low risk of bias, 11 studies had some risk of bias, and no studies had high risk of bias (Cohen's kappa = 0.58). **Conclusion:** Eleven of 18 diagnostic testing studies reported LOS reductions. POCT was the most common intervention type, and usually reduced EDLOS within relevant patient subsets, while triage-initiated testing generally did not. To aid widespread adoption, future research should focus on interrupted time series or RCT designs, and more comprehensive descriptions of the contextual factors affecting implementation of these interventions.

Keywords: crowding, point-of-care testing, throughput

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Triage drift: Variation in application of the Canadian Triage Acuity Scale between triage nurses compared to triage paramedics in response to overcrowding pressures in an emergency department

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Introduction: CTAS is a validated five-level triage score utilized in EDs across Canada and internationally. Moderate interrater reliability between prehospital paramedic and triage nurse application of CTAS during clinical practice has been found. This study is the first assessment of the variation in distribution of CTAS scores with increasing departmental pressure as measured by the NEDOCs scale comparing triage allocations made by triage nurses with those made by triage paramedics. **Methods:** We conducted a retrospective, observational cohort study of EDIS data of all patients triaged in the Halifax Infirmary Emergency Department from January 1, 2017-May 30, 2017 and January 1, 2018 - May 30, 2018. CTAS score assignment by nursing and paramedic triage staff were compared with increasing levels of ED overcrowding, as determined by the department NEDOCS score. **Results:** Nurses were more likely to assign higher acuity scores in all situations of department crowding; there was a 3% increased probability that a nurse, as compared to a paramedic, would triage as emergent when the ED was not overcrowded (Pearson chi-square (1) = 4.21, $p < 0.05$, Cramer's v = 0.028, n = 5314), and a 10% increased probability that a nurse, as compared to a paramedic, would triage a patient as emergent when EDs were overcrowded (Pearson chi-square(1) = 623.83, $p < 0.001$, Cramer's v = 0.11, n = 56 018). **Conclusion:** Increasing levels of ED overcrowding influence triage nurse CTAS score assignment towards higher acuity to a greater degree than scores assigned by triage paramedics.

Keywords: allied health personnel, Canadian Triage and Acuity Scale, triage

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Artificial intelligence to predict disposition to improve flow in the emergency department

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Introduction: Emergency department (ED) crowding is a major problem across Canada. We studied the ability of artificial intelligence methods to improve patient flow through the ED by predicting patient disposition using information available at triage and shortly after patients' arrival in the ED. **Methods:** This retrospective study included all visits to an urban, academic, adult ED between May 2012 and June 2019. For each visit, 489 variables were extracted including triage data that had been collected for use in the Canadian Triage Assessment Scale (CTAS) and information regarding laboratory tests, radiological tests, consultations and admissions. A training set consisting of all visits from April 2012 up to December 2018 was used to train 5 classes of machine learning models to predict admission to the hospital from the ED. The models were trained to predict admission at the time of the patient's arrival in the ED and every 30 minutes after arrival until 6 hours into their ED stay. The performance of models was compared using the area under the ROC curve (AUC) on a test set consisting of all visits from January 2019 to June 2019. **Results:** The study included 536,332 visits and the admission rate was 15.0%. Gradient boosting models generally outperformed other machine learning models. A gradient boosting model using all available data at 2 hours after patient arrival in the ED yielded a test set AUC 0.92 [95% CI 0.91-0.93], while a model using only data available at triage yielded an AUC 0.90 [95% CI 0.89-0.91]. The quality of predictions generally improved as predictions were made later in the patient's ED stay leading to an AUC 0.95 [95% CI 0.93-0.96] at 6 hours after arrival. A gradient boosting model with 20 variables available at 2 hours after patient arrival in the ED yielded an AUC 0.91 [95% CI 0.89-0.93]. A gradient boosting model that makes predictions at 2 hours after arrival in ED using only variables that are available at all EDs in the province of Quebec yielded an AUC 0.91 [95% 0.89-0.92]. **Conclusion:** Machine learning can predict admission to a hospital from the ED using variables that area collected as part of

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