**Updated questions:**

* Which patient groups are not correctly classified with the current triage system, i.e.:
  + Which patients at high risk of 7-day mortality, ICU admission, or direct surgery get incorrectly classified as low urgency?
  + Which patients at low risk of 7-day mortality, ICU admission, or direct surgery get incorrectly classified as high urgency?
* Are there any differences in performance of the 3 triage systems being used during the study period?

**Approach:**

* Perform unsupervised clustering to identify subgroups (e.g. elderly with a certain ICD-10 code cluster), also checking shift, hour, etc.
* For now, use ICD codes by groups, but consider re-grouping by clinical presentation, e.g., infection, trauma, etc.
* First use a composite outcomes using 7-day mortality, ICU admission, and direct surgery
  + Later look at individual outcomes at a later stage if sufficient N

Pro memori:

* in which of these misclassified patients could better classification result in better outcomes - currently insufficient data, but maybe Trondheim or Mimic-ER might capture this data
* Marcus: Can we predict correct/more accurate triage for patients after arrival, during ambulance drive or telephone using ML?

Can we use other methods, such as advanced statistics/probabilities methods, Graph theory, …?

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**Dot-dash outline**

**Introduction**

Merit of triage systems (DM)

The goal of Emergency Department (ED) triage is to identify and prioritize those with the most urgent needs to use the emergency service first. Several triage instruments have been developed, and most classify patients into different emergency levels based on symptoms and clinical signs[1]. Triage systems are often created based on expert opinion and are typically not validated[2]. The sensitivity of different triage systems varies, and critical patients presenting symptoms not readily recognized as indicators of criticality may be incorrectly classified as low-urgency[3-5]. The correct classification of high-acuity patients concerns patient safety because misclassification of high-acuity patients can cause a delay in diagnosis and treatment, potentially leading to morbidity or mortality. The correct classification of low-urgency patients increases the efficiency of the ED flow and reduces waiting times for truly high-urgency ED visits. Furthermore, the misclassification of low-urgency patients may lead to the over-use of limited recourses. There is no gold standard for classifying true patient urgency. Still, short term mortality and intensive care unit-admission (ICU) is often considered as a reference standard for high urgency, and discharge after ED visit a reference standard for low urgency [1, 6, 7].

* Current systems in use
  + Oslo university hospital: Manchester Triage System (MTS)
  + Sørlandet Hospital (Flekkefjord, Kristiansand, Arendal): Manchester Triage System (data from 2016)
  + Nordlandssykehuset (Bodø, Lofoten and Vesterålen): Rapid Emergency Triage and Treatment System (RETTS) (data from 2017)
  + St.Olavs Hospital (Trondheim): RETTS
  + University Hospital of Northern Norway (Tromsø, Harstad, Narvik, Longyearbyen): RETTS
* The Manchester Triage System was developed in the 1990s by a group of emergency physicians and emergency nurses in Manchester. Similar to SATS, MTS is a five level triage system developed for pre-and in-hospital emergency units.
* The Rapid Emergency Triage and Treatment System
* System at Bergen
  + The South African triage scale (SATS) is a noncommercial triage system developed in 2004 for pre-and in-hospital emergency units throughout South Africa. It contains an adult and a pediatric version[8]. In 2012, permission was obtained, and a modified version of SATS was implemented at the emergency department (ED) at Haukeland University Hospital, Bergen[9]. The English user guide is available on the web page of SATS Norge[10]. Previously, the triage system at Haukeland University Hospital was based on clinical gestalt.

Although there are several triage systems, the most commonly evaluated are the Canadian Triage and Acuity Scale (CTAS), the Emergency Severity Index (ESI) and the Manchester Triage System (MTS)[1][6].A relatively recent systematic review (SR) reported similar performances across these three triage systems, with none (also including the ATS and SATS) consistently demonstrating high reliability[1]. While most reported high sensitivity for identifying patients with ED mortality as high acuity at triage, the majority also reported low sensitivity in identifying patients with critical illness outcomes and death within days of an ED visit or during the index hospitalization[1]. The authors stated that further studies are needed to compare the performance of ED triage scales for clinically important outcomes and within different patient populations[1]. Another SR and meta-analysis reported that 33 types of triage systems have been evaluated in the literature, but that only the three presented above (i.e. CTAS, ESI and MTS) have been rigorously evaluated[6]. Given that performance was found to be variable - even within systems, the SR authors concluded that future research on triage systems should consider what factors may be influencing their performance, and how existing systems can be enhanced[6].

Other studies of triage systems have found different performance for different patient groups, including subgroups based on the main reason for presenting to the ED, age and race[5, 8, 9].

* Literature on performance of current triage systems and that of Bergen in particular
* Any real-world performance studies?
* Anything on misclassified patients in the published literature?

**Aim**

* Validate performance of Bergen triage system across subgroups
* Identified patient groups that are misclassified
* TBD: Validate findings in external data set (Trondheim, [**MIMIC-IV-ED v2.0**](https://physionet.org/content/mimic-iv-ed/))

**Methods (DM)**

Data source  
We conducted a single-center retrospective cohort study at the main ED at Haukeland University Hospital, Bergen, Norway. Haukeland University Hospital serves a population of approximately 500,000 and also functions as a referral hospital for approximately 1,000,000 inhabitants. Yearly ED admission during the study period ranged from 33,000 to 38,000. The ED handles patients with medical, surgical, and neurologic conditions. Children with medical conditions and females with obstetric conditions are treated elsewhere.  
Data was collected from the electronic health system used in the ED (Akuttdatabasen, Helse-Vest IKT, version 1.5.5., Stavanger) that contains both administrative data including time of admission, department, source of admission, patient’s national identification number, and clinical data such as age, gender and triage level. Using the national identification number, we linked the data to the Norwegian National Population Register, which contains information about deaths.

Inclusion criteria  
We included all patients that presented to the ED from January 2012 through September 2017. To ensure unambiguous patient identification and reliable information regarding mortality, we only included patients with a national identification number. The national identification number is an eleven-digit number that is assigned to all Norwegian citizens at birth, and to all residents upon immigration. It contains embedded information about date of birth and sex.

Variable definitions  
Triage nurses categorize patients into triage level 1- red (emergency), 2 - orange (very urgent), 3 - yellow (urgent), 4 - green (not urgent), or 5 - blue (can wait). The physician should assess the patient immediately if triaged to level red, within 10 minutes to level orange, within 60 minutes to level yellow, and within 120 minutes to level green. The triage level blue includes patients arriving for administrative causes or planned visits.

Outcome definition  
The reference standard for high-acuity was defined as 1) death within 24 hours after presentation to the emergency room, 2) transfer to the ICU from the ED, and/or 3) transfer to the surgical operating theater (including coronary angiography) directly from the ED. Mortality at 24-hours was collected as well as death within 7-day and 30-day from presentation to the ED. The composite of these outcomes are hereafter referred to as “severe illness”. In addition, mortality within seven days and 30 days after presentation to the ED was considered a proxy for high-acuity at admission. We considered discharge from ED (i.e., patients not admitted to hospital) as a reference standard for low-acuity.

* Data extraction
* Data cleaning
* Unsupervised clustering
* (external validation)
* etc.

**Results**

* Data set generation flow-chart (fig. 1)
* Characteristics of included patients (table 1)
* Results of the classification system and potentially misclassified groups (fig. 2)
* Factors associated with misclassification

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