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The Offload Zone as a Solution to the Offload Delay of the Emergency Medical Services

Research internship at Dalhousie University

Corine M. Laan, Peter T. Vanberkel, Richard J. Boucherie

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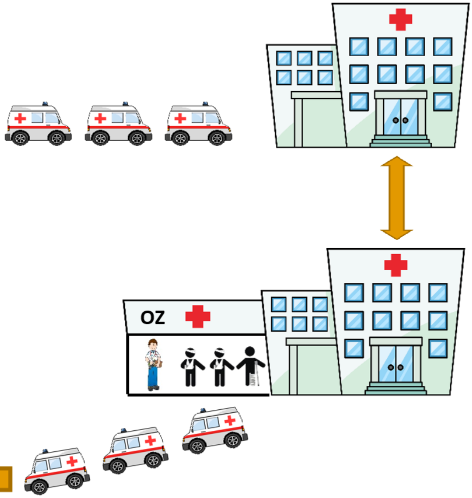
Introduction

- Overcrowding of the emergency department (ED) causes offload delay
- Ambulance cannot be used and patients do not receive the care they need
- Halifax Infirmary implemented an offload zone as a solution, which serves as a buffer between ambulance and emergency department

The offload zone

Without offload zone:
Ambulances queue, waiting to offload their patients

With offload zone:
Multiple patients wait with a paramedic and nurse, relieving the ambulances



Challenge

- A few months after implementation a decrease of the positive effect of the offload zone was noticed
- Anecdotal evidence suggests that patient selection (priority) changes when an offload zone is implemented

Approach

- Model emergency department with continuous time Markov chain, in order to investigate the impact of the offload zone
- Construct discrete event simulation to test this model and allow some additional metrics
- Compare different priority rules by means of these models

Continuous Time Markov Chain

- Three patient types:
  1. ambulance patients (high priority)
  2. walk-in arrival (high priority)
  3. low priority patients
- State space: $S = [N_b, N_b^H, N_1, N_2, N_3]$
  - N_b: ED beds in use (capacity: c)
  - N_b^H: ED beds in use by high priority patients
  - $N_t (t = 1, 2, 3)$: queue length of patient type t (max M_t)
- Arrival rate: $\lambda_t (t = 1, 2, 3)$
- Service rate μ_L, μ_H

Generator Matrix

Solve $\pi Q = 0$ to find π_s:

if $N_b^H \leq N_b < c$:

$$q_{(N_b,N_b^H,N_1,N_2,N_3),(N_b+1,N_b^H,N_1,N_2,N_3)} = \lambda_3 \qquad (N_1, N_2, N_3 = 0)$$

$$q_{(N_b,N_b^H,N_1,N_2,N_3),(N_b+1,N_b^H+1,N_1,N_2,N_3)} = \lambda_1 + \lambda_2 \qquad N_1, N_2, N_3 = 0)$$

$$q_{(N_b,N_b^H,N_1,N_2,N_3),(N_b-1,N_b^H,N_1,N_2,N_3)} = (N_b - N_b^H)\mu_L \qquad (N_1, N_2, N_3 = 0)$$

...

if $N_b^H \leq N_b = c$:

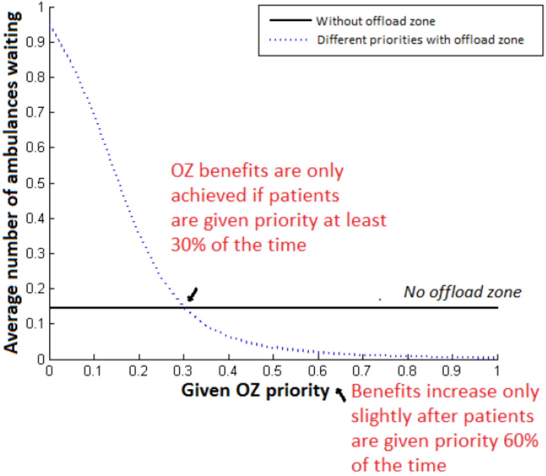
$$q_{(N_b,N_b^H,N_1,N_2,N_3),(N_b,N_b^H,N_1-1,N_2,N_3)} = p_{OZ} N_b^H \mu_H \qquad (N_b^H > 0; N_1, N_2 > 0)$$

$$q_{(N_b,N_b^H,N_1,N_2,N_3),(N_b,N_b^H,N_1,N_2-1,N_3)} = (1 - p_{OZ}) N_b^H \mu_H (N_b^H > 0; N_1, N_2 > 0)$$

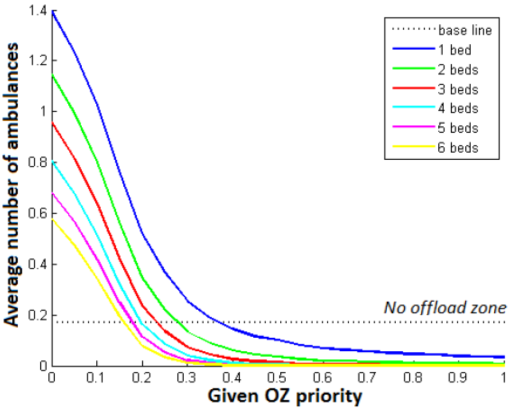
...

p_{OZ}: fraction of the time that priority is given to the offload zone

Results(1)


Without offload zone
Different priorities with offload zone
Average number of ambulances waiting
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Given OZ priority
No offload zone
OZ benefits are only achieved if patients are given priority at least 30% of the time
Benefits increase only slightly after patients are given priority 60% of the time

Results(2)


Average number of ambulances
Given OZ priority
No offload zone
base line
1 bed
2 beds
3 beds
4 beds
5 beds
6 beds
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0.1
0.3
0.5
0.7
0.9

Conclusion

- When priority is disproportionately given to walk-in patients, implementing an offload zone will actually increase offload delay
- In order to decrease offload zone delay, **priority has to be given to the ambulance patients in the offload zone at least a certain fraction of time**, depending on several factors, such as service load, number of beds and the patient mix