

Empirical Adventures in Hospitals

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Motivation

Why empirical?

- Can the data uncover interesting phenomena of hospital operation?
- Identify special characteristics of hospital environment.
- What are the operational implications of those phenomena?
- Explore impact of various operational schemes.
- Uncover interesting research questions.

Empirical vs. Statistical approach.

Literature

- **Queueing models for hospitals:**

- Capacity Planning: Green (2002); de Bruin, Bekker, van Zanten, and Koole (2009); Yom-Tov and Mandelbaum (2010).
- Patients' Routing: Mandelbaum, Momcilovic, and Tseytlin (2009)

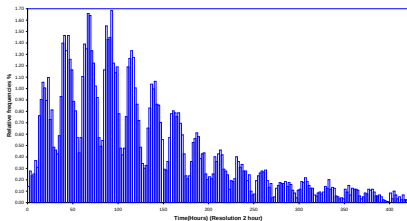
- **Empirically based research:**

- Chen, Harrison, Mandelbaum, van Ackere, and Wein (1988);
Adler, Mandelbaum, Nguyen, and Schwerer (1995);
Brown, Gans, Mandelbaum, Sakov, Shen, Zeltyn, and Zhao (2005);
Gurvich, Liberman and Mandelbaum (2010);

LOS Distribution

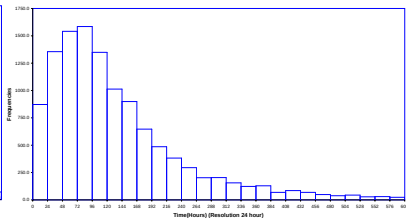
Two-hours resolution

Length of Stay (LOS), Internal Ward A
Hospital Data, 2004-01/2005



24-hours resolution

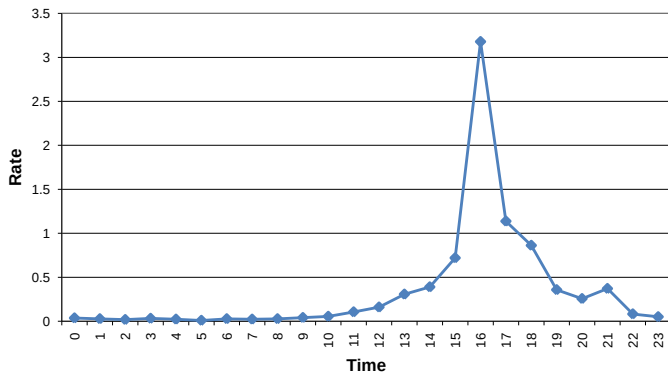
Length of Stay (LOS), Internal Ward A
Hospital Data, 2004-01/2005



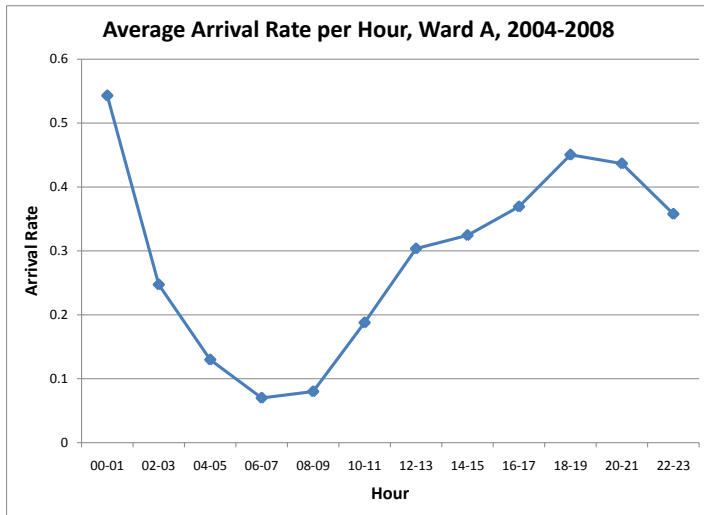
LOS is a mixture of Normally distributed Random variables.

IW Departure Rate

Average Departure Rate per Hour, Ward A, 2008

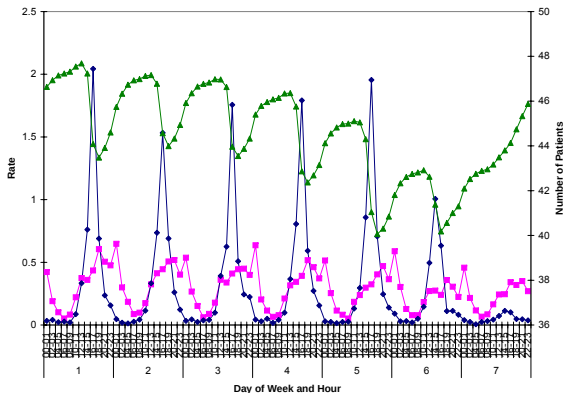


IW Arrival Rate



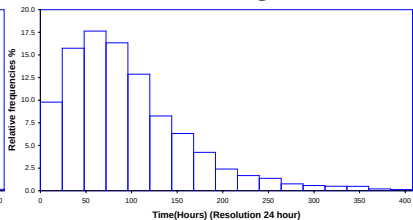
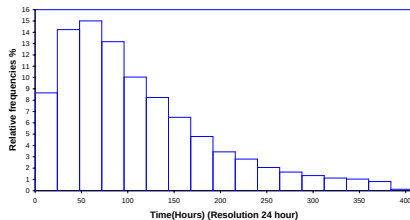
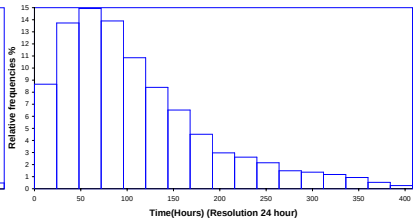
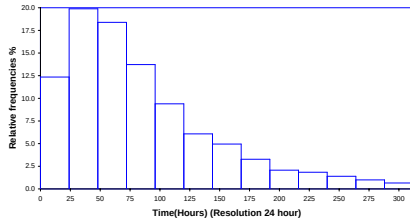
Patients, Arrival- and Departure-Rate

Arrival Rate, **Departure Rate**, and **Number of Patients** by
Day and Hour, Ward A, 2004-2008

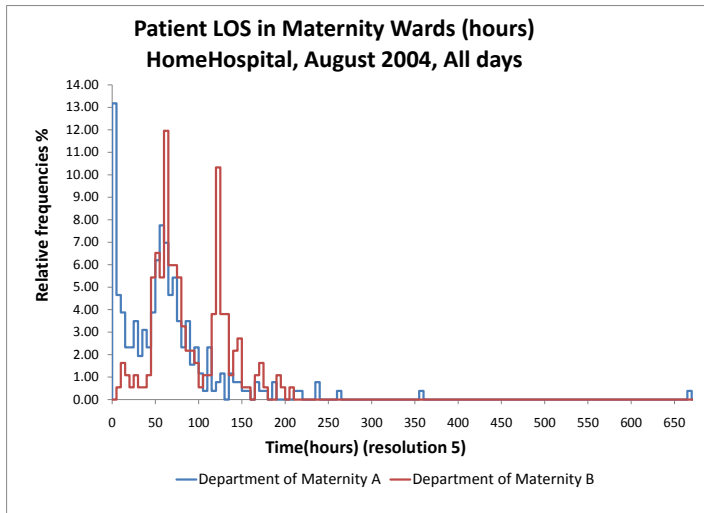


Number of patients changes dramatically over the day.
Operational effect: The effect of flux in time-varying queues.

LOS Distribution of IW B-E

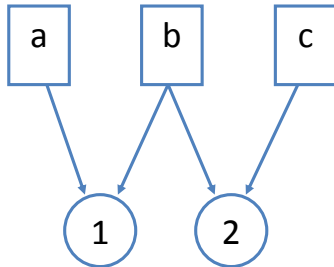


LOS Distribution of Maternity Ward

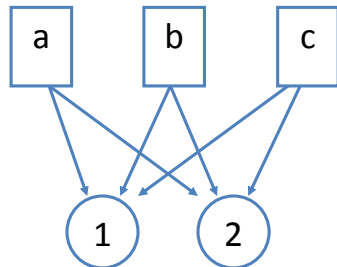


Routing Schemes in Different Wards

Maternity Ward



Internal Ward



Returns in IW and Oncology

Returns to hospital

Ward	No. of returns per patient (in 4 years)	Time between returns (days)	Probability of return within 3 month
Internal	1.76	208	22%
Oncology	5.76	29	76%

Conclusion

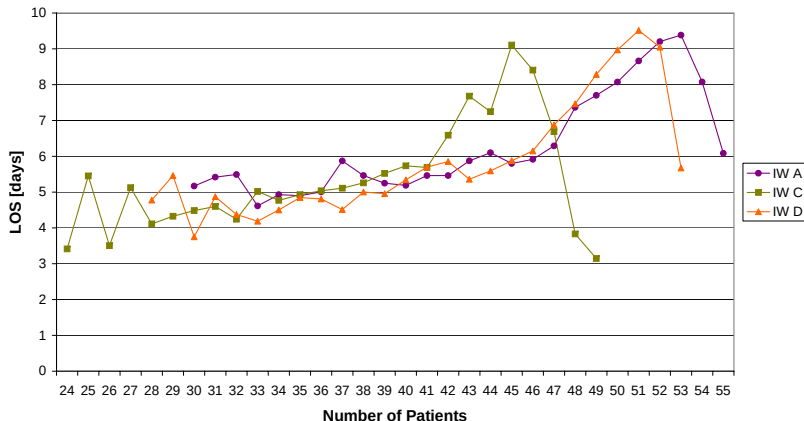
Queueing theory provides tools to model Healthcare operations, and the data analysis provides the means to:

- Implement models.
- Characterize environments where the models are applicable.
- Identify where these models are bound to fail and need adjustments.
- Better understand the system and discover new phenomena.

Thank You

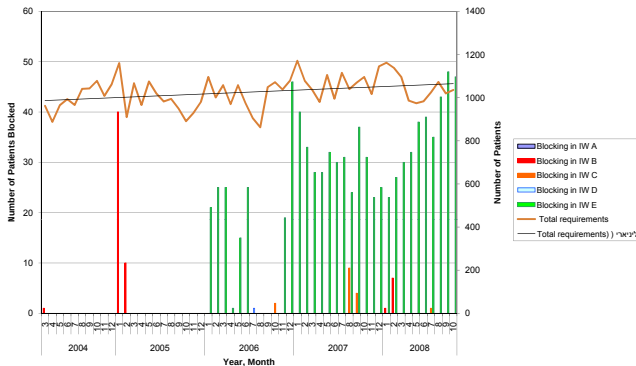
LOS and Load

LOS as a function of Load



Blocking

Total Blocking Incidents per Year and Month, all IWs



Trend in arrival rate explains part of the blocking.
 Beds capacity was reduced from 202 beds to 185.
 During 2006 War no blocking.
 Change in blocking policy.