

# Evaluation of the Efficiency in Healthcare using queueing modelling: A Case Study of Intensive Care Units in Kyiv

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## Abstract

Queueing theory gives suitable tools for studying special systems that model repeated execution of the same type of tasks that appear in many fields of production, household services, economy, finance, etc. Therefore such models are widely used for designing different types of stochastic objects. One of the goals of queueing theory is to calculate performance measures of the systems, in particular queue length, number of customers in the system, probability of refusals caused by a mismatch between the demand for a service and the capacity to satisfy the demand.

The healthcare industry around the world suffers from queueing refusals. Most commonly, this is a problem of estimating the level of service provided to patients, the cost of the medical service, the average waiting time, the number of patients in the queue, the capacity used and the probability that a patient needs to wait, or the probability of a patient being turned away when all service servers are occupied in the case of a non-queueing system. Hospitals should constantly improve their work, because poor planning and a faulty logistics system lead to excessively long stays.

Our work examines an intensive care unit, where certain urgent mechanical or pharmacological support is required. We consider an intensive care unit as a queueing system without waiting places (without a queue), where beds are model servers and patients are customers. The flow of customers, that is a flow of emergency patients, is supposed to be a Poisson one, such flows naturally appear in our case (patients arrive independently, usually one at a time, with stable intensity during a day). The rate of patient arrivals assumed to be constant. The time spent in the intensive care unit is determined by an exponential distribution.

By modelling the unit as a queueing system, we aim to study and evaluate the performance measures of the system such as the probability of patient rejection, the optimal number of beds in the unit, the rate of the arrival of patients per day, and the average time of patient service. We estimate parameters of the system based on the data for emergency unit in Oleksandriv Hospital of Kyiv. Having the parameters, we obtain the probability of refusal. Different optimization problems for the cost of the system service can be formulated and solved in order to find a balance between the average workload and the probability of failure.

Queueing and failure analysis can significantly improve medical productivity, patient satisfaction, and cost-effectiveness of health care. This determines the relevance of the study of the efficiency of the Oleksandriv Hospital and its comparison with the average Kyiv indicators. One of the purposes of the work is to identify the impact on the efficiency of intensive care units in Kyiv under changing the basic model parameters such as the number of beds, service time, and the arriving rate of patients.

**Keywords:** queueing model, failure probability, emergency department.

## References

Komenda I. (2013) *Modelling Critical Care Unit Activities Through Queueing Theory*. School of Mathematics, Cardiff University, Cardiff.

Yan Z., Jie Z., Min T., Jian S., Degang Z. (2022) *Forecasting patient arrivals at emergency department using calendar and meteorological information*. Hangkong University, Nanchang.

Creemers S., Lambrecht M. (2008) *Healthcare queueing models*. Catholic University Leuven, Belgium.