Analysis of the Cost Intensity of Transportation in the Polish Rescue Services System

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Abstract Polish Rescue Services System is one of the most important parts of the whole healthcare system in Poland. The paper is concentrated on the financial aspects of the transportation system of Rescue Services, precisely on the cost analysis. The place of the Rescue Services in the Polish healthcare system is presented. The different types of sanitary transports are discussed, and the calculation of the daily costs of ambulance teams is calculated and analysed. Such an analysis leads to a proposal of an optimisation model based on the classic transportation problems in operational research, which could be applied practically if the current division of the rescue areas was changed.

Keywords Rescue services · Cost intensity · Medical transport

Introduction

The care of public health is one of the first and foremost obligations of every government, which is also the case in Poland. This leads to a highly formalised structure of healthcare entities. The formalisation is especially high in those areas where the danger towards patient's life and health is especially visible. One of these areas is the Polish Rescue Services System which consists of many different sub-systems, out of which one of the most important ones is the transportation sub-system. From logistic point, the transportation services in the Rescue Services Systems are no different than classic transportation services. The difference lies,

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however, in the different way of measurement of the quality of those services, which is not done upon the moment of service but throughout the whole treatment process. At the same time, the quality of the treatment process is highly dependent on the quality of the Rescue Service at the very beginning of this specific healthcare cycle. This leads to a different set of goals regarding the transportation system and in turn, to a different structure of costs and a different potential for optimisation. In the paper, the cost values for the ambulance teams are calculated and the structure of those costs is further analysed, which in turn is the basis for the adaptation of an optimisation model, based on the classic transportation algorithms.

Rescue Services as a Sub-system in the Polish Healthcare System

The legal basis for the Polish healthcare system is laid out in a number of different legal acts, most importantly in the constitution, in which the 68. Article states that every member of the society has the right to the healthcare services and that those services are provided equally for every citizen regardless of his financial status. Those services are paid for from the public funds and that also includes the emergency Rescue Services.

The structure of the Polish healthcare system is a result of further legal acts, determining the regulations regarding the healthcare entities, the medical practitioners, including MDs, nurses, and auxiliary personnel and also the medical corporations. The financial situation is regulated through the system of healthcare services financed from the public funds, controlled by the National Health Fund. The citizens themselves come into contact with healthcare system either through acquiring healthcare services from different healthcare providers (e.g. hospitals, clinics and individual MDs) or, in a state of emergency, through the system of Rescue Services which is separately regulated by its own corresponding legal act and is directly subordinate to the prime minister (Fig. 1).

The Rescue Services System as such is comprised of two primary sections. The first section is made up of all voivodes in the country who are the representatives of the governmental administration and are responsible for coordination, control, planning and co-financing of the system. The second section is the executive one. It is made up of hospital emergency wards and of the Rescue Services teams which are complementary towards each other. Specifically, in the system there are four types Basic Rescue Services Teams, Specialist Rescue Services Teams, Airborne Rescue Service Teams and Hospital Emergency Wards [2].
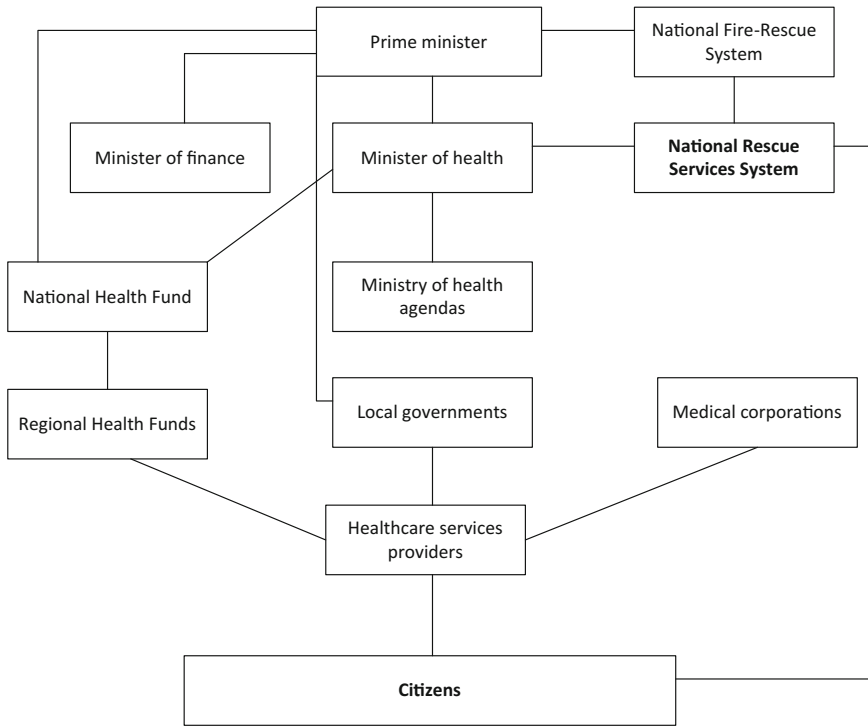
Fig. 1 Structure of the Polish healthcare system. *Source* Based on [1]

Transportation in the Rescue Services System

The legal regulations regarding the Rescue Services System in Poland specify the category of the sanitary transport, which is divided as follows:

- Rescue Service transportation,
- sanitary transport in the basic health care,
- remote transport in the basic health care and
- sanitary transport with an "N" ambulance.

The Rescue Service transportation, which includes the ambulance system, is connected with carrying out duties connected directly with saving lives in emergency situations. The rescuers which arrive at the scene in an ambulance perform first aid assistance, supply the patient with all the necessities and transport him to a hospital, if needed. The rescue team transports the patient to the nearest possible hospital emergency ward or to a hospital pointed out by the dispatcher or the coordinating doctor. There are two types of the Rescue Services ambulances: the basic ambulances and the specialist ambulances. The main objective of the basic ambulances, which are staffed with at least two licensed rescuers, including a

qualified nurse, is to transport the patient from the scene of the incident to the closest medical ward, according to the principle of "load and go". The specialist ambulances are sent by the dispatchers to those incidents, in which there is a possibility of aiding the patient directly at the scene of the incident. It is staffed with at least three licensed rescuers, including a specialist doctor and a nurse or a rescuer. The choice of which team to send to the scene of an incident is made by the dispatcher upon receiving the call, performing the initial interview and evaluating the situation.

Sanitary transport in the basic healthcare can be used by those patients, who have the necessity to receive a healthcare service in a certain healthcare provider or if there is a need to maintain the continuity of treatment. The sanitary transport includes the transport of the patient to the place in question and back and the decision on the necessity of transport is made by a specialist doctor. He is also the one who makes the decision regarding the payment for the service, which can be full, partial or null, depending on the illness and movement disorders.

Remote sanitary transport in basic healthcare can only be used in extraordinary situations and its performance has to be evaluated and approved by the director of the Regional Health Fund. It is provided if a patient, due to random causes, has to use healthcare services abroad and his condition is stable but does not allow for such a movement or in a situation in which a patient has to receive, due to a justified medical cause, a healthcare service in a specialist clinic which is located further away than 60 km from his house.

Sanitary transport with a neonatologic "N" ambulance is provided if there is a sudden decline in the medical state of a newborn child, specifically if there is a respiratory insufficiency, cardiac insufficiency or directly before or after surgeries performed in specialist hospitals [3].

The Costs of Transport in the Polish Healthcare System

Every submitted need for a transport service of people or cargo has a certain economic and social significance and is integrally connected with the proper functioning of the society and the country. The transportation services in the Polish Rescue Services System are connected with the performance of very specific transport services, and its effectiveness is an extremely significant factor for the overall quality of the healthcare services, and thus, it directly determines the state of the public health in the country.

The high significance of the transport services as well as its robust cost intensity implicates the need for a calculation of the costs of the healthcare teams so as to be able to plan the funding and identify the possible room for improvement.

The costs of the rescue teams can be estimated based on data regarding the two main cost categories:

- Direct costs of the rescue teams, specifically:
  - personnel costs and
  - running costs.

- Indirect costs of the rescue teams, most importantly including the administrative costs and the costs of the medical dispatchers.

The direct personnel costs are caused by the wages, salaries and all the benefits of the medical personnel working in the rescue teams, i.e. doctors, rescuers, nurses, paramedics and drivers.

The remaining direct costs are the result of the use of materials and energy, most importantly: medicines, dressing materials, antiseptic gauzes, disposable needles and syringes, cleaning materials, petrol, diesel or gas for the ambulances, spare parts and also external services of maintenance and repair of the ambulances and the remaining medical assets and the external services of contracting work.

The calculation was performed separately for the basic and the specialist rescue teams, on average in 2014, per one working day, in PLN (Table 1). The calculation was based on the division of costs according to their kinds—group "4" of the enterprise chart of accounts.

Table 1 Calculation of the daily costs of rescue teams in Poland

Cost group	Average daily cost of the specialist rescue team in 2014 (PLN)	Average daily cost of the basic rescue team in 2014 (PLN)
Depreciation	71.10	66.58
Use of materials and energy	152.52	189.74
External services (work related)	825.66	684.63
External services (other)	894.46	410.56
Taxes and duties	14.91	12.21
Salaries and wages	1308.44	892.13
Social insurance and benefits	261.46	152.02
Other direct cost	8.03	16.64
Total direct costs	3536.56	2424.50
Attributable indirect costs	603.19	565.90
Total cost	4139.75	2990.40
Total work-related costs	2395.55	1728.77

Source Own calculations based on [4]

The average daily cost for the specialist rescue team is 38% higher than the average daily cost for the basic rescue team. This is a result of the difference in two basic cost groups—the total work-related costs (including the cost of contracts with the involved medical practitioners, the cost of salaries and wages and the cost of social insurance and other benefits for the workers) are 666 PLN a day higher (38% higher) and the cost of other external services (connected with the maintenance of the specialist medical machinery) which is twice as high for the specialist rescue team. Overall, the highest expenditures are connected with the personnel (57% for both kinds of teams), other external services (22% for the specialist team and 14% for the basic team) and the use of materials and energy, mostly petrol (4% for the specialist team and 6% for the basic team). The first two of the aforementioned groups of costs are connected with reaching a proper quality of the medical Rescue Services. However, the cost of the use of materials and energy is mostly a result of the use of fuels and is thus correlated with the distance the ambulances cover. Those costs can be optimised based on a dispatcher choice and a proper route selection.

In practice, the costs of transport itself in the Rescue Service System in Poland is often much higher than it could possibly be due to an artificial division of metropolitan and rural areas into areas which are subordinate to a certain hospital emergency unit and to a certain dispatcher. This leads to a situation in which ambulances cannot cross the borders of their area even if the distance to cover would be a lot shorter for them than for an ambulance which is dispatched from within the area. This leads to a situation, in which the routes and therefore the costs of transport are optimised within the domain of a certain dispatcher while they are far from being optimised globally, within the whole system. Currently, in the Polish Rescue Services System, the voivodes are in power to change the delimitation of the dispatcher areas and thus change the system into a system of above regional patient service, which could then be easily optimised by a transformation into a classic transportation problem. In such a transportation problem, the Rescue Service would be the product, the patients would be the recipients and local Rescue Service dispatch stations would be the suppliers.

Formally, for the Rescue Services System, the transportation problem can be defined as follows:

- S—the number of the dispatch stations,
- R_s—number of regions covered by the dispatch station,
- T_{sr}—average distance from s-station to r-region,
- W_{-r}—number of ambulances dispatched to the r-region,
- W_s—number of ambulances dispatched from the s-station,
- x_{sr}—the variables—number dispatches from s-station to r-region and
- GF—goal function.

$$\text{GF} = \sum_{s=1}^{S} \sum_{r=1}^{R_1 + \cdots + R_S} x_{sr} * T_{sr} - > \min \tag{1}$$

$$\sum_{r=R_s+1}^{R_s-1+R_s} x_{sr} \leq W_s * M_s; \quad s = 1, \ldots S \tag{2}$$

$$\sum_{s=1}^{S} x_{sr} \geq W_{-r}; \quad r = 1, \ldots R_1 + \cdots + R_S \tag{3}$$

Assuming that the regions are delimited, it is possible to optimise the dispatch system in the Rescue Services System regarding the total distance covered and in consequence to achieve the minimal possible fuel consumption cost while still providing an equal availability of the Rescue Services for all the patients in a certain area [5].

Conclusions

The cost intensity of transportation in the Polish Rescue Services System is significant and is a result of a number of factors. While calculating the costs of the ambulance rescue units, one has to take into account the costs of all the personnel, external services, including the maintenance of the specialist machinery and the cost of the use of materials and energy, including the cost of fuel. The personnel costs, which are the dominant group, are a result of the legal obligation regarding the indispensable staff in an ambulance unit. The machinery costs are also more connected with the service of first aid than the transport itself. However, the fuel costs are a result of the dispatch decisions and route choice and can therefore be subject to optimisation. However, the current divisional structure of the Rescue Services areas creates with artificial borders. That makes it impossible to optimise the system cost-wise. If the system were changed, which it can be if the voivodes so decide, then it could be optimised using the algorithms of classic transportation operational research.

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