



**THE ANALYSIS OF LOGISTICS  
IN SELECTED HEALTHCARE FACILITIES  
AND THE EHEALTH PERSPECTIVES IN THE SLOVAK REPUBLIC**

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**Abstract:** *The paper aims to determine the level of logistics and of the supply chain principles implementation in healthcare facilities in Eastern Slovakia and focuses on eHealth implementation in the selected facilities. The study presents a regression analysis of the data obtained using a questionnaire. Firstly, our results show that the level of logistics in healthcare facilities is linked to the flow of information, flow of supplies and the management level. Secondly, it shows that there is direct evidence between the logistics implementation, quality of services provided, and economic indicators. Finally, we found no evidence of a relation between e-Health implementation ambitions and its positive and negative effects.*

**Key words:** *Logistics, Management, Healthcare Facilities, e-Health*

## 1 INTRODUCTION

Lack of financial resources in a healthcare system is a symptom of deficiency in numerous economies. Efficiency of healthcare facilities is a crucial factor that can lead a healthcare system to economic efficiency. Information is a crucial factor in logistics. It has to be relevant and delivered to its user at the right time. Nowadays, the problem of information flows in health-care facilities is that information is disseminated in a parallel way in paper-based and digital documents.[1] Budget constraints draw attention to the supply of materials as a way of cutting costs.[2] The structure of healthcare network can lead to economic efficiency as well. Mahar et al. developed a model of a hospital network with multiple locations aiming to leverage pooling benefits. Their study deals with both the patient service levels and their economic aspects. [3] Advantages of teamwork in economic and personal fields are commonly known. [4] Nabelsi determines key performance indicators which should be used by managers of healthcare facilities and mentions that managers use a small number of key performance indicators and they do not necessarily ascribe the same relative importance to them. [5] Kritchanai and Suwandechochai have diagnosed the hospital's internal supply chain and logistics system using a business process analysis. [6] Rohner and Mettler have analysed the theoretical foundations of supplier relationship management and explored a particular area of its application in healthcare. Also applications of different supplier relationship management services are treated. [7] Sedlmayr et al. introduced an example of technology adoption to optimize mainly logistic processes, cost-effectiveness, quality and safety. [8] [9] Whitacre et al. studied the factors determining outsourcing of health information technologies in hospitals. [10] Van de Klundert et al. discuss optimization problems that have to be solved when redesigning processes of material flow and its availability and cost reduction in hospitals. [11] Villa et al. have proposed a reorganized patient flow logistics and they draw attention to clinical, operational, and economic issues. [12] Aptel and Pourjalali take a closer look at the logistics-related differences among hospitals in the United States and France. Beside other findings, authors advocate that Just-in-Time philosophy needs to be applied by hospitals in the process of inventory cost reduction. [13]

This paper is organized as follows: section 2 presents goals, assumptions and hypotheses, section 3 presents materials and methodology, in section 4 results are presented, and section 5 is a concluding remarks section.

## 2 GOALS, ASSUMPTIONS AND HYPOTHESES

The main purpose of this study is to provide a clear overview of the application of logistics principles in healthcare facilities in Eastern Slovakia. Therefore, we perceive our main goal as a sequence of three partial goals.

*1<sup>st</sup> partial goal:* Evaluation of hospital logistics in selected healthcare facilities as a whole and in light of the particular logistic flows. In this stage we aimed to discover how top-level managers and first-level managers perceive the present level of hospital logistics as a result of partial logistic flows (flow of laundry, flow of food, flow of medicaments and medical supplies, flow of patients, flow of information, flow of waste, flow of personnel, flow of supplies). Here our Hypothesis 1 is as follows: Logistics principles application in healthcare facilities is not possible without partial logistic flow application.

*2<sup>nd</sup> partial goal:* Analysis of opinions of healthcare facilities personnel regarding the implementation of hospital logistics and its impact on quality and economic indicators. In this

stage we studied the effects of hospital logistics on economic outcome and quality of provided healthcare. Here our Hypothesis 2 is as follows: There is statistical evidence of a relation between the economic impacts of logistics principles implementation and the quality of services and processes.

**3<sup>rd</sup> partial goal:** Analysis of attitudes of healthcare facilities personnel to eHealth implementation efforts considering its negative and positive effects. Here Hypothesis 3 is as follows: There is a statistical relation between eHealth implementation and the evaluation of its positive and negative side effects.

### 3 MATERIALS AND METHODOLOGY

The objects of this study are public and private healthcare facilities in Eastern Slovakia. In this area, there are 26 healthcare facilities that meet the given criteria. Respondents are top-level and first-level managers. A questionnaire was sent out to 156 managers operating in 26 different healthcare facilities. In total 87 questionnaires were returned, but we had to exclude 6 respondents due to their answers being too homogenous (these questionnaires came from the same hospital). Therefore, the questionnaire response rate was 53.8 %. The questionnaire consisted of 55 questions and was distributed during the months of May and June 2011. The questionnaire is available upon request. The percentage of female and male respondents was 38 % and 62 %, respectively. Top managers accounted for 53 % of all the respondents, while first-level managers for 47 % of all the questionnaires. Table 1 shows the distribution of subjects according to the number of employees in the facility and according to its capacity.

*Tab. 1 Distribution of subjects according to the number of employees and number of beds*

Number of employees	n	%	Number of beds	n	%
<b>1-99</b>	2	3.2	<b>1-99</b>	2	3.2
<b>100-299</b>	17	20.9	<b>100-299</b>	44	53.7
<b>300-499</b>	33	40.2	<b>300-499</b>	23	28.3
<b>500-999</b>	17	20.9	<b>500-999</b>	0	0
<b>1000 and more</b>	12	14.8	<b>1000 and more</b>	12	14.8
$\Sigma$	81	100	$\Sigma$	81	100

As illustrated in Table 1, we can conclude that the majority of the subjects in our analysis come from large-sized organizations in terms of the number of employees and number of beds.

### 4 RESULTS

Results of our study are divided into three parts, according to the partial goals described in section 2: Goals, assumptions and hypothesis.

**1<sup>st</sup> partial goal:** At first we present the results concerning the attitudes of managers to the most important logistic flows in a hospital. Respondents had to choose on a five-degree Likert scale, where 1 means very good management of the logistic flow and 5, on the other side of the scale, means very poor management of the logistic flow. Table 2 depicts the satisfaction of personnel with the individual logistic flows. Based on Table 2 we can conclude

that in the selected healthcare facilities the personnel is rather satisfied with individual logistic flows. However, there are some weaknesses concerning the flow of laundry, flow of medicaments, flow of information and the flow of supplies. The strengths of the individual logistic flows are perceived in relation to the flow of food, flow of patients, flow of waste, and in the flow of personnel.

Then we extended our analysis by performing regression and we estimated an ordinary least squares model and an ordered logit model. By doing so, we aimed to determine to what extent the perceived level of hospital logistics as a whole is the result of the satisfaction with the individual logistic flows.

**Tab. 2** Attitudes of managers to the most important logistic flows in hospitals (in %)

<b>Logistic flow</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b><math>\Sigma</math></b>
<b>flow of laundry</b>	9	48	24	19	0	100
<b>flow of food</b>	14	57	12	12	5	100
<b>flow of medicaments</b>	8	53	15	24	0	100
<b>flow of patients</b>	4	68	22	6	0	100
<b>flow of information</b>	8	57	11	24	0	100
<b>flow of waste</b>	7	55	32	6	0	100
<b>flow of personnel</b>	7	60	20	13	0	100
<b>flow of supplies</b>	4	48	26	22	0	100

Results of the regression analysis are shown in Table 3. As we can see, the results of both regressions are similar.

**Tab. 3** Regression analysis

	<b>OLS model</b>		<b>OL model</b>	
<b>Identification</b>	<b>Coefficient</b>	<b>SE</b>	<b>Coefficient</b>	<b>SE</b>
<b>Logistics</b>	0.127	0.166	0.612	0.455
<b>Laundry</b>	0.126	0.134	0.348	0.413
<b>Food</b>	-0.090	0.091	-0.408	0.318
<b>Medicaments</b>	-0.081	0.103	-0.242	0.370
<b>Patients</b>	-0.034	0.141	-0.295	0.453
<b>Information</b>	-0.307***	0.087	-1.149***	0.306
<b>Waste</b>	-0.044	0.146	0.235	0.512
<b>Personnel</b>	0.109	0.125	0.469	0.467
<b>Supplies</b>	0.277***	0.121	1.149**	0.474
<b>Management level</b>	0.313***	0.138	1.44**	0.569
<b>Intercept</b>	4.015***	0.821		
<b>R<sup>2</sup></b>	60.63 %		<b>LR test</b>	0.946
<b>R<sup>2</sup> adj</b>	50.72 %		<b>Wald test</b>	0.004***
<b>max VIF</b>	2.79			
<b>BP test</b>	0.000***			
<b>RESET</b>	0.751			
<b>Shapiro Wilk test</b>	0.001***			
<b>F test</b>	0.007***			

Factors affecting the subjects' perception of the level of hospital logistics as a whole as the result of their satisfaction with the individual logistic flows are the same in both

regressions: the flow of information, the flow of supplies, and the management level. In the case of the flow of information, the results show that the more one is satisfied with this variable, the more they identify with the hospital logistics. Concerning the flow of supplies, the relation differs. The less one is satisfied with the flow of supplies, the more they identify with the hospital logistics implementation. The result concerning the management level shows a few interesting points. We distinguished two levels of management: the first -level management and the top management. When one was from the top management, their identification with hospital logistics was greater by 0.313. The OL model indicates that top managers tend to identify themselves more with hospital logistics.

To conclude, we can state that there is statistical evidence of a relation between the individual logistic flows and the identification of managers with the principles of the hospital logistics. Therefore, Hypothesis 1 was not rejected.

**2<sup>nd</sup> partial goal:** Here, at first in Table 4, we present the attitudes of the respondents to economic indicators and quality of services provided in connection with hospital logistics implementation. Respondents were asked to answer whether logistics has an impact on economic performance and quality. The agreed variable was scaled as follows: definitely yes, rather yes, neutral, rather not, definitely not.

**Tab. 4** Impact of logistics on economic indicators and quality of services provided in hospitals

<b>Economic performance</b>	<b>n</b>	<b>%</b>	<b>Quality of services</b>	<b>n</b>	<b>%</b>
<b>definitely yes</b>	58	71	<b>definitely yes</b>	40	50
<b>rather yes</b>	19	24	<b>rather yes</b>	30	37
<b>neutral</b>	4	5	<b>neutral</b>	10	12
<b>rather no</b>	0	0	<b>rather no</b>	1	1
<b>definitely not</b>	0	0	<b>definitely not</b>	0	0
$\Sigma$	81	100	$\Sigma$	81	100

When eyeballing Table 4 it is evident that managers are aware of the importance of logistics in hospitals in terms of economic efficiency and quality. To test our hypothesis, we excluded one answer “rather not” in the question concerning quality of services provided. The value of chi-square test equal to 17.428 and p value 0.000 indicate that there is statistical evidence between the perception of the influence of hospital logistics implementation on economic efficiency and the perception of its influence on quality. The results are shown in Table 5.

**Tab. 5** Contingency table – perception of economic indicators and quality of services provided

<b>economic indicators / quality of services</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>4</b>	4	13	2
<b>5</b>	4	16	38
<b>Pearson chi<sup>2</sup></b>	17.428		
<b>p-value</b>	0.000		
<b>Cramér</b>	0.476		
<b>Kandall tau-b</b>	0.450***		

Kandall tau-b coefficient indicates that the relation between the perceptions of economic and qualitative influences of hospital logistics implementation is direct; therefore, Hypothesis 2 was not rejected.

**3<sup>rd</sup> partial goal:** At first we present the attitudes of managers to the positive and negative effects of eHealth implementation. The respondents were asked to answer whether eHealth has a positive impact on the given field of the study, or a negative one. The ordinal variable was scaled as follows: 1-definitely yes, 2-rather yes, 3-neutral, 4-rather not, 5-definitely not. Table 6 shows the attitudes of managers to the positive effect of eHealth implementation.

**Tab. 6** *Expectation of a positive effect of eHealth implementation (in %)*

<b>Positive effects of eHealth</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Σ</b>
<b>increase in productivity of work</b>	53	44	3	0	0	100
<b>cross-border cooperation</b>	27	53	20	0	0	100
<b>increase in quality</b>	34	56	10	0	0	100
<b>cost reduction</b>	25	49	16	10	0	100
<b>reduction of duplicate examinations</b>	61	35	4	0	0	100

From Table 6 it is evident that the managers of healthcare facilities are aware of the positive effects of eHealth. They are aware mainly of the advantages related to the reduction of duplicate examinations and increase in productivity of work. Table 7 shows the attitudes of managers to the negative effects of eHealth implementation.

**Tab. 7** *Expectation of a negative effect of eHealth implementation (in %)*

<b>Negative effects of eHealth</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Σ</b>
<b>protection of private data</b>	10	28	20	42	0	100
<b>rise of skills requirement</b>	4	41	11	40	4	100
<b>system launching problems</b>	15	52	13	20	0	100
<b>costs growth</b>	5	20	20	54	1	100
<b>changes in legislation</b>	10	65	15	10	0	100

Table 7 shows that managers have negative sentiments in connection with the legislative changes, requirements regarding employees' skills, and problems with launching of the whole eHealth network. Managers do not see a problem in terms of private data protection and the rise in costs. To test our Hypothesis 3, we estimated logarithmic regression with a binary dependent variable. We estimated two models in total. The first one explained eHealth implementation efforts as a matter of positive effects and the second one as a matter of negative effects. If a respondent answered rather yes, we transferred their answer to 0, if they answered yes; we transferred their answer to 1. Results for positive effects are presented in Table 8.

**Tab. 8** Logarithmic regression with binary dependent variable for positive effects

<b>Logarithmic regression</b>		
<b>eHealth</b>	<b>Coefficient</b>	<b>SE</b>
<b>Productivity</b>	-0.893*	0.523
<b>Cooperation</b>	-0.031	0.458
<b>Quality</b>	-0.759	0.486
<b>Cost reduction</b>	0.815	0.291
<b>Duplicities</b>	0.502	0.593
<b>Management</b>	0.334	0.510
<b>Wald Test</b>		0.322

The model presented in Table 8 is not statistically significant; therefore, we have no evidence of the eHealth implementation positive effects and of attitudes of personnel to eHealth implementation. Table 9 presents results of the regression for negative effects.

**Tab. 9** Logarithmic regression with binary dependent variable for negative effects

<b>Logarithmic regression</b>		
<b>eHealth</b>	<b>Coefficient</b>	<b>SE</b>
<b>Private data</b>	0.253	0.243
<b>Skills requirements</b>	-0.163	0.245
<b>Launch problems</b>	0.736***	0.332
<b>Cost growth</b>	0.378	0.308
<b>Legislation</b>	-0.893**	0.379
<b>Management</b>	0.681	0.563
<b>Wald test</b>		0.062*

This model is statistically significant at the 0.1 significance level. Variables Launch problems and Legislation seem to be significant. Respondents that do not expect negative effects of eHealth implementation consider this process advantageous. These results indicate that there is not a regression model explaining positive attitudes to eHealth implementation using its positive effects and negative effects. According to our results, we reject Hypothesis 3.

## 5 CONCLUSIONS

In our study we focused on the logistics of healthcare facilities and eHealth implementation process in the Slovak Republic. Firstly, we have found out that the main weaknesses of the logistics in Slovak hospitals concern the flow of laundry, flow of medicaments, flow of information and flow of supplies. Strengths in logistic flows are seen in relation to the flow of food, flow of patients, flow of waste and the flow of personnel. Second finding is that managers in healthcare facilities are aware of the importance of logistics in hospitals in terms of economic efficiency and quality of services provided. Furthermore, we have found out that the members of the higher level of management identify themselves with hospital logistics more than the members of the first-level of management. Concerning eHealth implementation, managers see the main threats in legislative changes, requirements regarding employees' skills and problems with the launch of the whole eHealth network. Managers do not see a problem in terms of private data protection and the rise of costs. We found statistical evidence of a relation between the individual logistic flows and the identification of managers

with the principles of hospital logistics. We also showed the relation between the perception of economic improvements and the perception of qualitative ones thanks to hospital logistics implementation. There is no evidence of positive attitudes to eHealth implementation using its positive effects and negative effects.

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