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doi:10.15199/48.2019.01.06

IT reliability and the results of accredited laboratories functioning in Poland

***Abstract**. The article indicates the need to apply IT solutions in research and reference laboratories operating in Poland in the context of measurable benefits. The results of empirical studies carried out in 84 laboratories are presented. Most of the surveyed entities declare the use of standard (typical) information systems, and almost three-fifths use specialized software dedicated to the laboratory's field of activity. Oddly enough, entities declaring the implementation of typical IT solutions have lower performance parameters than those that do not. The analysis confirms that the use of (reliable) IT in research and reference laboratories allows to achieve measurable benefits in these entities in all areas of their functioning. Reliable IT supports, among others, processes in the laboratory (including identification and elimination of possible disturbances), has a positive impact on the quality of services, management efficiency and increases the level of competitiveness.*

***Streszczenie.** W artykule wskazano na konieczność stosowania rozwiązań IT w laboratoriach badawczych i wzorcujących funkcjonujących w Polsce w kontekście możliwych do uzyskania, wymiernych korzyści. Przedstawiono wyniki badań empirycznych przeprowadzonych w 84 laboratoriach. Większość badanych podmiotów (trzy czwarte) deklaruje stosowanie standardowych (typowych) systemów informacyjnych, a prawie trzy piąte posługuje się specjalistycznym oprogramowaniem dedykowanym dla obszaru działalności laboratorium. Co dość dziwne, organizacje deklarujące wdrożenie typowych rozwiązań IT odnotowują niższe parametry wynikowe niż te, które ich nie stosują. Analiza potwierdza, że stosowanie niezawodnego IT w laboratoriach badawczych i wzorcujących pozwala na osiągniecie w tych podmiotach wymiernych korzyści we wszystkich obszarach ich funkcjonowania. Niezawodne IT sprzyja m.in. prawidłowym przebiegom procesów w laboratorium (w tym identyfikacji i eliminacji ewentualnych zakłóceń) wpływa pozytywnie na jakość usług, sprawność zarządzania i podniesienie poziomu konkurencyjności laboratoriów. Wzrostowi niezawodności IT towarzyszy wzrost parametrów wynikowych funkcjonowania badanych laboratoriów (**Niezawodność IT a rezultaty akredytowanych laboratoriów badawczych i wzorcujących funkcjonujących w Polsce**)*

K**eywords**: management, IT reliability, laboratories
Słowa kluczowe: zarządzanie, IT, niezawodność , laboratoria

Introduction

Previous research carried out in research and reference laboratories operating in Poland and having an accredited management system were related to many aspects of their functioning. In particular, in 2010-2017, empirical studies were carried out aimed at: analysis of the process and effects of implementation of management systems according to ISO / IEC 17025, also in the context of the time of use of these systems (Bieńkowska, 2012), identification of TQM compliance in laboratories (Bieńkowska, 2013), analysis of the relation between TQM maturity and results obtained by laboratories (Bieńkowska, 2015), or discussion on the process of building relationships based on trust (Bieńkowska et al., 2017).

One of the current aspects of laboratories operations is the use of information technology (IT) in the process of shaping the quality of the research service. Nowadays it is obvious that the collection, processing and transfer of data is not possible without proper IT support (Bieńkowska & Tworek, 2018). For this reason, the aim of this study is to diagnose the use of IT solutions in research and reference laboratories operating in Poland. The paper describes the results of empirical studies conducted among 84 laboratories. They constitute research material allowing to verify the hypothesis: the higher is the IT reliability in research and reference laboratories, the higher are the measurable benefits obtained by these units in all areas of their functioning.

1. The Quality Of The Research Service And The Use Of It In The Process Of Its Development

The quality of research and reference services is obtained by the laboratory as a result of the implementation of activities included in the process of its provision. This process, in general, includes both technical and managerial activities. Technical activities relate to individual phases of the service implementation, i.e. from the moment of identifying the customer's needs and expectations, selecting research methods and technical base, purchasing, supervising measurement and research equipment, validating test methods, testing or calibrating, through verifying, interpreting and preparing results, delivering results to the customer and receiving feedback - thus until it is determined whether expectations have been met. Management actions are including the implementation of all management functions at strategic, tactical and operational levels in relation to all technical activities (Bieńkowska & Bieńkowski, 2012).

At every stage of the broadly understood research and / or reference service it is possible (and even necessary) to use IT solutions. Wattanasri and colleagues (2010) emphasize that IT (namely laboratory information systems (LIS)) is one of the elements whose importance in the context of quality of accredited laboratories has been growing in recent years. Other authors also emphasize that adequately selected and implemented IT is a factor not only potentially affecting the quality of laboratory operations, but also a condition for their ability to function in the modern world (Bieńkowska & Tworek, 2018; Radisic-Biljak et al., 2012). In the literature, the role of IT in information flow management in laboratories is also emphasized (Radisic-Biljak et al., 2012), in particular in the supervision of documentation - in the process of creating, approving, distributing, reviewing and archiving documents (Berwouts et al., 2010), in knowledge management of laboratory employees (Wattanasri et al., 2010) and in standardization and automation of tasks performed in laboratories (Sepulveda and Young, 2013).

However, it should be emphasized that nowadays analysis of IT solutions in organization cannot be limited only to the analysis of the frequency of their use. In a world, where almost every organization (including research and reference laboratories) uses some kind of IT solutions (Chan, 2000), one should look for a method of their analysis allowing to assess their actual usefulness and adaptation to the needs of the organization. In this article, the analysis of IT reliability in the organization (based on the IT reliability model developed by Tworek (2016, 2018)) was used for this purpose. IT reliability is a measurable property of IT in

organization, useful for their control and management, identifying their level of quality and indicating potential problems. Therefore, reliability can be understood as effectiveness of IT components critical to its proper functioning. On this basis, Tworek (2016) proposed the model of IT reliability in the organization, which consists of 4 elements: system reliability (including usage reliability), reliability of information contained in this system and reliability of technical support of the system. This model will be used to assess IT reliability in research and reference laboratories.

2. Research methodology

Empirical studies in research and reference laboratories operating in Poland were carried out in June-September 2018. The aim of the research was to diagnose the use of IT in the analyzed units. The research tool was a questionnaire. The research covered laboratories having an accredited management system whose email addresses were on PCA websites (access: www.pca.gov.pl, dated 5-6.06.2018). The research was anonymous. The questionnaire included the following questions:

- identifying whether IT solutions used in laboratories are based on typical software, or whether specialized software is used, dedicated to areas of activity in which the laboratory operates;
- measuring IT reliability in an organization according to the methodology of K. Tworek (2018) specifying reliability of system, usage, information and technical support building overall IT reliability;
- referring to the results of laboratory operation in the areas of: quality, customers, processes, financial situation, management efficiency and the competitiveness of laboratories.

The questionnaire also included questions concerning selected characteristics of entities to determine the structure of the examined laboratories.

3. Research sample characteristic

The population of research and reference laboratories having an accredited management system is equal 1384 entities (including 1251 research laboratories and 133 reference laboratories). In the conducted empirical studies, 84 Polish accredited laboratories were tested, which constitutes about 6 percent of the population. The sample is not representative, but it can be used to study general trends observed in the surveyed entities. The structure of respondents was characterized primarily due to the organizational form of the laboratory, its size, duration of laboratory operation and accreditation as well as the position occupied by the respondent. The numbers of laboratories in particular groups are shown in tab. 1. The average time of functioning of tested laboratories was equal almost 20 years (SD = 19.66), and the average "accreditation period" equals over 5 years (SD = 5.45).

4. Research results

4.1. The use of IT in the tested laboratories

The results show that 85.7% of the tested laboratories use typical IT solutions (e.g. Microsoft Excell, Access), but slightly less, although also more than half: 66.6% use specialized IT solutions dedicated to the laboratory's field of activity. The organizational form of the laboratory does not affect applied (typical or specialized) IT solutions. The size of the laboratory is also not a factor differentiating the use of typical solutions. However, it can be stated (with the $\chi 2$ test – statistically significant differences were indicated), that in larger laboratories, i.e. employing more than 10 people, specialized software is used more often than in smaller entities ($\chi 2(3, N = 86) = 10{,}004$, $p = 0{,}019$). An interesting result was obtained during the analysis of the length of operation of the laboratories and their accreditation in the context of IT implementation. Initially, it was shown that the longer the laboratory operates, the less frequently it uses typical solutions, and more often uses specialized ones. In the case of the length of operation with accreditation there are no such relations, although there is a statistically significant positive relation between two variables: the longer the laboratory operates, the longer the time it operates with accreditation (the value of the Spearman correlation coefficient: $r(64) = 0{,}460^{**}$, $p < 0{,}001$).

4.2. IT reliability in the tested laboratories

To assess IT reliability in the examined laboratories, 4 elements of the IT reliability model were used: system reliability (software and hardware), usage reliability, information reliability and support service reliability. Descriptive statistics of those variables are presented in tab. 2. Table . also presents the average values of the variables studied for laboratories with typical and specialized IT solutions.

Table 1. Number of laboratories in different groups. Source: own work

Numner of laboratories in groups:		Number	[%]
Organization form (n=83)	Individual entity	30	36,2
	Part of Higher Education Institution	6	7,2
	Part of R&D Department	16	19,2
	Different	31	37,4
Number of employees (n=84)	Over 5 people	17	20,3
	6-10 people	18	21,4
	11-20 people	18	21,4
	Above 20 people	31	36,9
Respondent (n=83)	Administrative personel	7	8,4
	Executive personel	31	37,4
	Manager of the laboratory	44	53,2

Table 2. IT reliability – sample characteristics. Source: own work

Variables	N	min	max	M	SD	M for typical IT solutions	M for specialized IT solutions
System reliability	74	1,00	5,00	3,73	0,59	3,65	3,63
Information reliability	83	1,00	5,00	3,85	0,66	3,72	3,60
Support service reliability	79	1,00	5,00	3,33	0,79	3,38	3,39
IT reliability	72	1,02	5,00	3,61	0,61	3,56	3,56

Table 3. The use of IT solutions and laboratories performance parameters. Source: own work

Laboratories performance parameters	Use of typical IT solutions:	N	M	SD	t
Every year, we increase revenues from our operations.	YES	72	2,18	1,47	$t(82) = -2,43$; $p = 0,017$
	NO	12	3,25	0,87	
The level of our competitiveness is constantly growing.	YES	72	2,20	1,12	$t(82) = –3,07$; $p = 0,003$
	NO	12	3,41	1,92	
The accredited management system in the laboratory functions efficiently.	YES	72	3,48	0,55	$t(82) = -2,07$; $p = 0,041$
	NO	12	3,83	0,39	

Table4. Correlation between IT reliability (system, information and support service) and laboratories performance parameters. Source: own work

	System reliability	Information reliability	Support service reliability	IT reliability
The quality of services in our laboratory is high.	r(74)=0,411** p<0,001	r(83)=0,352** p=0,001	r(79)=0,377** p=0,001	r(72)=0,467** p<0,001
The quality of our laboratory services is constantly increasing.	r(74)=0,315** p=0,006	r(83)=0,260* p=0,018	r(79)=0,301** p=0,007	r(72)=0,347** p=0,003
We have a permanent group of loyal customers.	r(74)=0,284* p=0,014	r(83)=0,286** p=0,009	r(79)=0,234* p=0,038	r(72)=0,339** p=0,004
We manage to win new clients every year.	r(74)=0,437** p<0,001	r(83)=0,334** p=0,002	r(79)=0,237* p=0,036	r(72)=0,388** p=0,001
All processes in our laboratory run without major disturbances.	r(74)=0,567** p<0,001	r(83)=0,509** p<0,001	r(79)=0,312** p=0,005	r(72)=0,518** p<0,001
The existing disturbances in the course of processes are immediately identified.	r(74)=0,509** p<0,001	r(83)=0,512** p<0,001	r(79)=0,222* p=0,049	r(72)=0,448** p<0,001
The identified disturbances in the course of processes are immediately eliminated.	r(74)=0,420** p<0,001	r(83)=0,421** p<0,001	r(79)=0,215 p=0,057	r(72)=0,393** p=0,001
Every year, we increase revenues from our operations.	r(74)=0,262* p=0,024	r(83)=0,254* p=0,021	r(79)=0,275* p=0,014	r(72)=0,325** p=0,005
We are constantly reducing the costs of our operations.	r(74)=0,226 p=0,053	r(83)=0,224* p=0,041	r(79)=0,218 p=0,054	r(72)=0,269* p=0,022
The level of our competitiveness is constantly growing.	r(74)=0,344** p=0,003	r(83)=0,296** p=0,007	r(79)=0,236* p=0,036	r(72)=0,360** p=0,002
Organization management is efficient.	r(74)=0,412** p<0,001	r(83)=0,279* p=0,011	r(79)=0,371** p=0,001	r(72)=0,424** p<0,001
Orders are processed on time.	r(74)=0,441** p<0,001	r(83)=0,366** p=0,001	r(79)=0,169 p=0,136	r(72)=0,374** p=0,001
The accredited management system in the laboratory functions efficiently.	r(74)=0,396** p<0,001	r(83)=0,279* p=0,011	r(79)=0,271* p=0,016	r(72)=0,375** p=0,001

IT reliability in tested laboratories is assessed as a relatively high (M > 3.6 for all variables except for the reliability of support service, which is averagely rated lower, although still positive - M = 3.33). The obtained results also indicate that laboratories, which use typical IT solutions have a significantly higher level of information reliability than laboratories, which use specialized solutions (ΔM = 0,12). Typical IT solutions are much more flexible and offer greater opportunities to adapt to the information needs of a particular organization than specialized IT solutions, which usually provide standard functionalities, which do not offer the possibility of any customization. It is also worth noting that almost all laboratories filled in the part of questionnaire concerning information reliability (83 out of 84 tested laboratories), while the part concerning system reliability was omitted by 9 respondents. Moreover, it was the component of IT reliability averagely assessed more positively than others (M = 3,85, which is the highest value from all IT reliability components). It shows that reliability of information is an important factor in research and reference laboratories, and necessity for its management is understood by respondents well.

4.3. The use and reliability of IT and the performance parameters of tested laboratories

In order to verify the impact of using typical and specialized IT solutions on laboratories performance parameters, analysis was carried out using Student's t-test for independent tests. Performance parameters of the laboratories were compared between those, which declare the implementation of typical and specialized IT solutions and those, which declare the lack of its implementation. For three performance parameters, the analysis of the Student's t-test showed statistically significant differences between laboratories using and not using typical IT solutions (see table 3). It should be emphasized that if laboratory does not use typical IT solutions, its performance parameters are better, while the use of specialized IT solutions positively influences some of the presented performance parameters (which is shown by the average values, but unfortunately is not confirmed by the Student's t-test).

The relations between IT reliability and the laboratories performance parameters was analyzed using r-Pearson correlation, assuming a critical level of significance of 0,05. Correlation coefficients for all analyzed components of IT reliability and laboratories performance parameters are summarized in tab. 4.

Empirical research results, presented in table 4, clearly indicate that there is a statistically significant correlation between IT reliability (and the reliability of the system itself, the information contained therein, and its support service) and the laboratories performance parameters. The strongest relation occurs between IT reliability and variable „All processes in our laboratory run without major

disturbances" (r = 0,518, p = 0,001) and „The quality of services in our laboratory is high" (r = 0,467, p = 0,001). In addition, it is worth noting that almost in every case, the reliability of the system itself is the component of IT reliability characterized by the highest correlation values (in the case of „All processes in our laboratory run without major disturbances" it achieves the highest result for all analyzed correlations: r = 0,567, p = 0,001). The reliability of information shows a lower level of correlation with performance parameters, although still statistically significant - the strongest correlation occurs with the variable: „The existing disturbances in the course of processes are immediately identified" (r = 0,512, p = 0,001). The reliability of support service often shows a significantly lower level of correlation with performance parameters (the strongest correlation occurs with the variable „The quality of services in our laboratory is high" (r = 0,377, p = 0,001)), and in some cases the correlation is statistically insignificant. Finally, it should be noted that relatively weak dependencies, or their lack, were indicated between IT reliability in all analyzed aspects and the level of revenues and costs of the laboratory's operations. This is of course perfectly understandable, because IT reliability can only indirectly affect these specific performance parameters. The increase in revenues is directly influenced by the acquisition of new customers (r = 0.582, p <0.001), disturbance-free course of processes (r = 0,366, p < 0,001) and high quality of service (r = 0,325, p = 0,002). The reduction of the costs of the laboratory's activity is most strongly affected by the acquisition of new clients (r = 0.333, p = 0.002) along with the disturbance-free course of processes (r = 0.220, p = 0.041), which are influenced by reliable IT.

5. Conclusions

The presented research results allow for the positive verification of the hypothesis formulated in the introduction, which states that the higher is the IT reliability in research and reference laboratories, the higher are measurable benefits obtained by these entities in all areas of their operations. Moreover, the results show that IT reliability (especially system reliability) has a strong relation primarily with the correct course of processes in the laboratory and then (as a result) with the quality of services performed in it. It is consistent with the view of Radisic-Biljak and colleagues (2012), that the role of IT in information flow management in laboratories has a potential to influence the course of processes for their benefit. What is more, information reliability has the strongest relation with the identification of disturbances in the course of processes, which means (assuming the right direction of impact) that the quality of information provided by IT to laboratory staff and decision makers (in particular, information accuracy and relevance) affects the rate at which weak signals are captured and the ability to remove disturbances effectively. However, a certain lack of trust in IT from laboratory staff is surprising. The very fact of using IT (typical and specialized) is critically assessed by the respondents. Laboratories that declare the implementation of typical or specialized IT solutions declare lower performance parameters than those in which these systems are not used. This probably means that the very fact of IT implementation is not important, but its reliability, which seems to be confirmed in the results of the research presented above. Once again, it seems to be consistent with the views from the literature (Chan, 2000; Tusubira & Mulira, 2004). Tusubira and Mulira (2004) are underlining that nowadays emplyees of every kind of organization are forced to use IT solutions on daily basis and there is a need for shaping those solutions in a way, which will allow those organizations to obtain benefits from their use.

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REFERENCES

[1] Berwouts, S., Morris, M. A., Dequeker, E. (2010), *Approaches to quality management and accreditation in a genetic testing laboratory*, European Journal of Human Genetics, 18(S1), S1.

[2] Bieńkowska A. (2015), *Dojrzałość TQM a efektywność organizacyjna akredytowanych laboratoriów badawczych i wzorcujących funkcjonujących w Polsce*, Przegląd Elektrotechniczny, R. 91, No 1, pp. 108-111.

[3] Bieńkowska A. (2013), *Principles of Total Quality Management - results of empirical research for testing and calibration laboratories functioning in Poland*, Przegląd Elektrotechniczny, R. 89, No 12, pp. 199-202.

[4] Bieńkowska A. (2012), *Wdrażanie systemu zarządzania według normy ISO/IEC 17025 w laboratoriach badawczych i wzorcujących - wyniki badań empirycznych*, Przegląd Elektrotechniczny, R. 88, No 12b, pp. 251-254.

[5] Bieńkowska A., Bieńkowski P. (2012), *Zrozumieć naturę zapewnienia jakości usług badawczych.* W: Zastosowania elektromagnetyzmu w nowoczesnych technikach i informatyce, [XXII Sympozjum Środowiskowe PTZE], Sandomierz, 9-12 września 2012, Warszawa, Polskie Towarzystwo Zastosowań Elektromagnetyzmu, pp. 33-36.

[6] Bieńkowska A., Bieńkowski P., Zabłocka-Kluczka A. (2017), *Kształtowanie kultury zaufania w laboratoriach badawczych i wzorcujących*, Przegląd Elektrotechniczny, R. 93, No 3, pp. 256-259.

[7] Bieńkowska A., Tworek K., *Wykorzystanie rozwiązań IT w laboratoriach badawczych i wzorcujących*, W: Zastosowania elektromagnetyzmu w nowoczesnych technikach i medycynie, [XXVIII Sympozjum Środowiskowe PTZE], Racławice, 9-12 września 2018, Warszawa, Polskie Towarzystwo Zastosowań Elektromagnetyzmu, pp. 44-46.

[8] Chan, Y. E. (2000), *IT value: The great divide between qualitative and quantitative and individual and organizational measures*, Journal of Management Information Systems, 16(4), pp. 225-261.

[9] PN-EN ISO 17025 (2005): *Ogólne wymagania dotyczące kompetencji laboratoriów badawczych i wzorcujących*, Polski Komitet Normalizacyjny.

[10] Radisic-Biljak, V., Ozvald, I., Radeljak, A., Majdenic, K., Siftar, Z., Vucic Lovrencic, M., & Flegar-Meštrić, Z. (2012), *Validation of a laboratory and hospital information system in a medical laboratory accredited according to ISO 15189*, Biochemia medica: Biochemia medica, 22(1), pp. 86-91.

[11] Sepulveda, J. L., Young, D. S. (2013), *The ideal laboratory information system*, Archives of Pathology and Laboratory Medicine, 137(8), pp. 1129-1140.

[12] Tusubira, F., & Mulira, N. (2004), Integration of ICT in organizations: Challenges and best practice recommendations based on the experience of Makerere University and other organizations. In International ICT Conference Held at Hotel Africana, Kampala, Uganda. 5th to 8th September.

[13] Tworek, K. (2016), *Model niezawodności systemów informacyjnych w organizacji.* Zeszyty Naukowe. Organizacja i Zarządzanie/Politechnika Śląska, (88), pp. 335-342.

[14] Tworek, K. (2018), *Information systems reliability in the context of higher education institutions*, 10th annual International Conference on Education and New Learning Technologies: Conference Proceedings, Palma de Mallorca (Spain), 2nd - 4th of July, 2018, IATED Academy.

[15] Wattanasri, N., Manoroma, W., Viriyayudhagorn, S. (2010), *Laboratory accreditation in Thailand: a systemic approach*, American journal of clinical pathology, 134(4), pp. 534-540