

Systemy Logistyczne Wojsk
Zeszyt 59 (2023)
ISSN 1508-5430, s. 37-54
DOI: 10.37055/slw/186389

Institut Logistyki
Wydział Bezpieczeństwa, Logistyki i Zarządzania
Wojskowa Akademia Techniczna
w Warszawie

Military Logistics Systems
Volume 59 (2023)
ISSN 1508-5430, pp. 37-54
DOI: 10.37055/slw/186389

Institute of Logistics
Faculty of Security, Logistics and Management
Military University of Technology
in Warsaw

Determinants of warehouse safety - theory and practice

Determinanty bezpieczeństwa magazynu – teoria i praktyka

Andrzej Roman Szymonik

dgw_szymonik@op.pl, ORCID: 0000-0002-7846-3959

Department of Supply Chain Management, Faculty of Organisation and Management, Technical University of Lodz, Poland

Abstract. In every warehouse, processes are carried out that have a static and dynamic character. They take place in a variable environment, which is planned and random, caused by various threats. A helpful tool that allows you to effectively manage warehouse management in a safe way is the analysis of everything that is related to the processes carried out in crisis situations. Previous analyzes conducted in Poland suggested that this area requires further research, which was presented in four sub-chapters: three theoretical and one practical. The aim of the work was to identify and evaluate tools and practices that positively influence safety in warehouses in Poland, in the years 2019-2022. The publication posed: a research problem in the form of a question: to what extent do the functioning technical and non-technical systems affect warehouse management in emergency situations (1)? two research gaps, the first manifests itself in the lack of studies on identifying threats affecting warehouse security, and the second practical, related to the lack of such research (2); hypothesis - identification of threats and technical factors affects warehouse security (3). The research was conducted using a questionnaire, in which threats and factors affecting safety in warehouses were analyzed. The presented results allowed to specify the threats that may appear in warehouse management, assess them and propose technical solutions that affect warehouse security

Keywords: warehouse, warehouse processes, threats, security, reliability

Abstrakt. W każdym magazynie są realizowane procesy, które mają charakter statyczny i dynamiczny. Przebiegają one w zmiennym środowisku, mającym charakter planowy i przypadkowy, spowodowany różnymi zagrożeniami. Pomocnym narzędziem pozwalającym skutecznie realizować gospodarkę magazynową w sposób bezpieczny jest analiza tego wszystkiego co związane jest z realizowanymi procesami w sytuacjach kryzysowych.

Prowadzone wcześniejsze analizy w warunkach Polski zasugerowały, że obszar ten wymaga dalszych badań, które zostały przedstawione w czterech podrozdziałach: trzy teoretyczne i jeden praktyczny.

Celem pracy była identyfikacja i ocena narzędzi oraz praktyk pozytywnie wpływających na bezpieczeństwo w magazynach w Polsce, w latach 2019 -2022.

W publikacji postawiono: problem badawczy w postaci pytania: w jakim stopniu funkcjonujące systemy techniczne i pozatechniczne wpływają na gospodarkę magazynową w sytuacjach zagrożeń (1)? dwie luki badawcze, pierwsza przejawia się brakiem opracowań dotyczących identyfikacji zagrożeń mających wpływ na bezpieczeństwo magazynu, a druga praktyczna, związana z niedoborem takich badań (2); hipotezę – identyfikacja zagrożeń i czynników technicznych wpływa na bezpieczeństwo magazynu (3). Badania zostały przeprowadzone za pomocą ankiety, w której analizowano zagrożenia oraz czynniki wpływające na bezpieczeństwo w magazynach. Zaprezentowane wyniki pozwoliły skonkretyzować zagrożenia, które mogą się pojawić w gospodarce magazynowej, dokonać oceny oraz zaproponować rozwiązania techniczne wpływające na bezpieczeństwo magazynów.

Słowa kluczowe: magazyn, procesy magazynowe, zagrożenia, bezpieczeństwo, niezawodność

Introduction

In every warehouse, there are processes that have a static and dynamic character. They take place in practice in a variable, turbulent environment that has a planned and random character, caused by various threats. The most difficult thing is to deal with the latter, which appear randomly. A helpful tool that allows to effectively and efficiently carry out warehouse management in a safe way is the analysis of everything that is related to the processes carried out and the search for tools for appropriate actions in crisis situations. For this purpose, research was carried out, starting from the analysis of literature, and then to the formulation of the goal:

- research problem, formulated as a question: to what extent do the functioning technical and non-technical systems affect warehouse management in situations of a wide range of threats?
- two research gaps, the first of which manifests itself in the lack of systemic studies on the identification of threats affecting warehouse security, and the second practical, related to the lack of research on the application, evaluation and recommendation of technical solutions affecting the functioning of warehouse management in the context of security.

The research objective was to identify and evaluate tools and practices that positively influence the safety in warehouses, in Poland and the hypothesis was that identification of hazards and technical factors affects the warehouse safety.

The research was conducted using survey research, from 2019 to 2022 in Poland, in enterprises conducting warehouse management.

Literature review

To develop this article, a rich literature on the subject was used, consisting of numerous journal and book publications with both national and international scope. This wide scope is the result of the topic undertaken in this article. It should be noted that warehouse security is a key element of any company, which on the basis of system analysis can be treated as: warehouse property characterizing its

resistance to the occurrence of dangerous situations (threats) and ability to protect stocks and infrastructure from external and internal threats as suggested in (Sowa, 2018, pp. 285-219; Schuetz, 2022). Warehouse security management begins with the identification of threats that affect the course of logistic processes. This problem was investigated in (Sienkiewicz, 2003, 9; Szymonik, Stanisławski, 2023, 5-10, Hofstra et al., 2018, pp. 134-148). Not insignificant for minimizing losses of accumulated resources in warehouses, in unplanned situations are actions related to such factors as: technical equipment, organizational and employed personnel as suggested in (Larco, de Koster, Roodbergen, Dul, 2013, pp. 6407-6422; Forcina, Falcone, 2021, pp. 436-445). On the other hand, the evaluation of the actions taken in the area of warehouse security would not be possible without own research, which was conducted by the author since 2015, which is reflected in his own and co-authored publications (e.g. two authorial publications, one published at the Lodz University of Technology, in Lodz 2016, the other in Difin, Warsaw in 2016, and one co-authored publication published in New York: Routledge /Taylor & Francis Group in 2022).

Warehouse as a static-dynamic object

A warehouse is a functional-organizational unit, having a planned space (Chojnacki, 2019, pp. 19-31) for carrying out logistic processes in it, which are subject to constant changes and transformations. Their final effect sometimes does not have a course previously determined and planned, due to the changing environment in which the flow of material and information stream carried out in the warehouse takes place. Here is the translation from Polish to English:

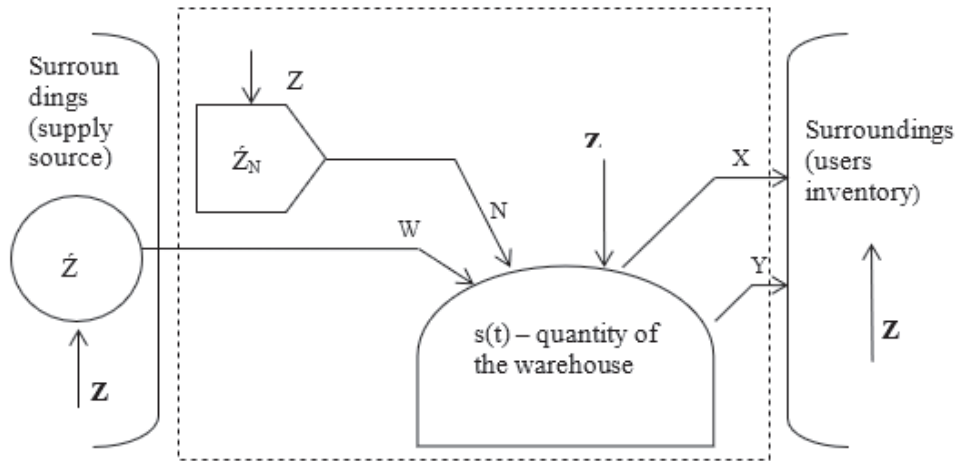
When evaluating the functioning of a warehouse, the following should be taken into account:

- static elements (e.g. organization, equipment, purpose);
- dynamic elements (e.g. picking, issuing);
- unplanned situations (threats) that affect the safety of logistic processes (Balan et al., 2016, pp. 1028-1034).

Therefore, the mapping of the warehouse functioning must be based on the three described components, which are useful in designing logistic simulation experiments.

The warehouse being an object of modeling can be presented as a system consisting of (Fig. 1).

In the functioning of the warehouse, one can distinguish: the object - i.e. the processes carried out over the accumulated stocks; the user - i.e. part of the reality surrounding the object; environment - the object and user are connected by relations with other external elements, which influence their behavior; internal and external relations - the ability to ensure the functioning of the object and user and “establishing” contacts with the environment and influencing the situations that arise there.



Legend:

$\dot{Z}W$ - source of stocks, from which the warehouse receives stocks according to e.g. signed contracts; $\dot{Z}\dot{N}$ - source of stocks (e.g. returns from production, returns from customers) coming from the environment independently of the warehouse; W - stocks coming to the warehouse from sources $\dot{Z}W$; N - stocks coming to the warehouse from sources $\dot{Z}\dot{N}$ occurring in the environment as quantities independent of the warehouse; X - stocks leaving the warehouse according to plan; Y - stocks leaving the warehouse not according to plan (e.g. unsuitable for theft); $s(t)$ - quantitative state of stocks in the warehouse at time t ; Z - disturbances caused by threats.

Fig. 1. Warehouse as an object

Source: Szymonik, Smal, 2019

The internal properties of the warehouse, like any system (object), can be analyzed in the context of such quantities as: capacity for different types of resources; optimization of warehouse stocks/resources; efficiency; resistance to disturbances of implemented processes; operational technical performance indicators; costs of warehouse activity; satisfaction and safety of personnel; others (Ferrer, 2023) [access: 08.02.2023].

Topology of threats

Ensuring the security of the warehouse is not possible without the need to use human, material and financial resources. The potential and size of resources allocated to warehouse security depends, among other things, on: external threats; internal threats, which are “accumulated” in it itself; warehouse resistance to threats; management effectiveness. Extremely helpful in assessing the “harmfulness” of

threats to warehouse security is their full identification, which we can divide into five groups (Staniecka, 2021, pp. 135-148).

- The first are natural threats, which include cataclysms, natural disasters, disasters, floods, drownings, strong winds and hurricanes. In this group we can distinguish events caused by deliberate action or negligence of man, and an example may be failures, fires.
- The second group includes civilizational events, such as: cyberattacks, electromagnetic waves, civilizational diseases, improper management of natural and financial resources, epidemics and pandemics.
- The third group includes social threats that undermine the constitutional order of the state (states), such as terrorism, road blockades, illegal demonstrations, conflicts on ethnic grounds, mass migration.
- The fourth group of hazards includes hazards resulting from mental disorders, which are a consequence of improper selection of working conditions, related to non-compliance with occupational safety, ergonomics, burnout.
- The fifth group includes technical failures such as: damage or destruction of warehouse infrastructure, power failures, water supply failures.

Disturbances in warehouse processes from the point of view of functions and levels of management may result from: incorrect assumptions for strategic planning purposes, incorrect assessment of strategic options; loss of reputation and social responsibility due to events of inappropriate or unreliable internal processes, applied unreliable technologies in the warehouse, inadequate level of physical security of assets and people; inadequate preparation of IT resources.

Selected indicators affecting the warehouse safety

Warehouse safety is defined as a set of rules and best practices aimed at ensuring a safe work environment. Since warehouse work largely relies on human labor and the use of appropriate equipment, a key factor is compliance with relevant rules and work safety, including ergonomics.

Warehouse safety is also a state that provides a sense of security and guarantee: the implementation of warehouse processes; information flow for planning and managing logistics processes; protection and survival in times of dangerous situations (threats); adaptation to new conditions (susceptibility to unplanned situations).

A certain level of warehouse security can be achieved in many ways - not only by ensuring a certain effectiveness of direct counteraction to existing events.

The controllable quantities in this case are parameters characterized by factors affecting the level of warehouse security, i.e. related to: prevention, preparation, resources, removal of the consequences of a given event.

Ensuring warehouse security is impossible without the need to use separate, properly trained and equipped forces and means ensuring survival and implementation of logistics processes for specific economic entities.

It should be taken into account that in a systemic approach, warehouse security is related to threats, reliability and risk. We use quantitative or qualitative measures to assess these quantities, remembering about a uniform approach for a given warehouse. The warehouse security system should be adapted to its potential threats and the desired level of security that must be provided to it. The amount of resources necessary to ensure a certain level of security in the area of logistics activities depends on the type, scale and forecasts of occurrence of unplanned situations.

An important sphere for the functioning of the warehouse is its security, which on the basis of system analysis we can treat as (Sienkiewicz, 2003, p. 9):

- a property of the warehouse that characterizes its resistance to the occurrence of dangerous situations (threats), with the focus on the reliability of the warehouse security, i.e. its susceptibility to the occurrence of dangerous situations;
- the ability to protect the stocks and warehouse infrastructure from external threats.

The security in the warehouse depends on three groups of factors, i.e. technical - more extensively in research, legal and personal - Table 1.

Table 1. Factors determining safety in a warehouse

Factor	Contents
Technical	Warehouse equipment and infrastructure (more in the research)
Legal (organizational)	Documentation and its implementation as well as procedures minimizing the risk of an accident or material loss.
Staff	Competences, qualifications and experience, professional development of the staff

Source: Own study

Technical factors affecting safety in warehouses are related to proper equipment and infrastructure, which ensure proper storage, internal transport, order picking, sorting, dispatch and proper protection of the facility and the goods stored there. The safety of people working in the warehouse and the material resources (stocks) deposited there also depends on the infrastructure. Helpful tools and instruments in this area include: Internet of Things (IoT) - RFID technology in combination with sensors, software and other technologies, which allows tracking inventory, via the Internet, with extensive use of cloud computing and big data, 5G, blockchain, machine learning; Warehouse Management System (WMS) - an information system supporting warehouse process management using appropriate IT tools (Whiting, 2023) [access: 21.07.2023];

Material Flow Management System (MMS) - an extension of the traditional warehouse management system; warehouse work automation systems - using various control systems to handle with minimal or reduced human intervention in the implementation of warehouse processes. Legal (organizational) factors include the development of documentation and its implementation as well as the development of procedures, whose strict observance minimizes the risk of an accident (de Vries, de Koster, Stam, 2016, 1377–1390) or material losses. An extremely important factor in warehouse safety is the staff working there (Ferrer, 2023) [access: 08.02.2023].

It is a team of people working in warehouses and performing activities directly related to its activity. According to the qualification tariff, the positions in warehouses include: warehouse manager, senior warehouseman, warehouseman, warehouse worker. The number of employees and their qualifications depend on the purpose and size of the warehouse. When selecting employees, one should take into account: competencies, qualifications and experience, and when they are already employed, do not forget about their professional development.

Warehouse safety - own research

Research method The research started with a literature analysis (using the method of literature criticism) in order to formulate the research problem and determine the research gap characterized by the topic. Based on the acquired material, it turned out that the problem of safety in warehouses, in Poland, is not sufficiently appreciated, as evidenced by the few publications and scientific research in this field. This situation suggested that this area requires further research.

The above conclusions forced the author of the article to formulate two research gaps related to the assessment of the importance of applied practices in the field of safety, which are implemented in enterprises conducting warehouse activity.

The first theoretical gap manifests itself in the lack of model solutions regarding the application of modern solutions aimed at safety in warehouses in Poland. The second practical (empirical) one is related to the lack of research on the application, evaluation, and recommendations of solutions affecting the functioning of warehouse management in the context of safety. The research was conducted between 2019 and 2022, using survey research and a questionnaire specially prepared for this purpose. In the proper research:

- The selection of the research sample began with the selection of 600 enterprises conducting warehouse management. Then 160 companies were randomly selected and subjected to research. Completed questionnaires were received from 130 companies.
- CAWI, auditory and individual techniques were used.

Characteristics of the research sample

The research was conducted mostly in the group of small and medium enterprises (67.2%), in warehouses: high storage (46.2%), medium storage (38.5%), mechanized 60.4% and automated 35.3%. The questions included in the survey were divided into two groups. The first was related to threats that may appear in warehouse management. This group included external threats, internal non-technical threats, internal technical threats. The second concerned technical factors influencing safety in warehouses. The questions concerned equipment and infrastructure that ensure proper storage, internal transport, order picking, sorting, dispatching and proper protection of the facility.

Analysis and evaluation of threats classified into the first group

External threats, affecting the security of the warehouse, have been classified into five areas, as shown in Figure 1. It shows that in the last three years, we have most often dealt with natural (heat, floods, droughts, pandemic) and technical threats. In the case of the former (several times and systematically), they occurred in 60 companies and the latter - 56 times.

External threats that occurred least frequently were civilizational, personality and social. This result shows that the people managing the warehouse economy perform their duties well, comply with the law and take advantage of the favorable economic situation of the country and low unemployment.

The degree of negative effects of external threats on the functioning of the warehouse economy is presented in Figure 2. According to the data, out of five types of external threats, the most troublesome in terms of consequences are natural threats, which also occur most often (only a large and very large impact of threats was taken into account). Analysis of internal non-technical threats in the warehouse. Based on the assessment of the answers to the question in the survey: what internal non-technical threats occurred in your warehouse in the last three years? it should be stated that those that did not occur "never" and "once" concern (Table 2):

- loss of goods for shipment - 115 cases (88.40%);
- lack of financial liquidity - 105 cases (80.70%);
- loss of contract / disruption of supply chain - 92 cases (70.70%).

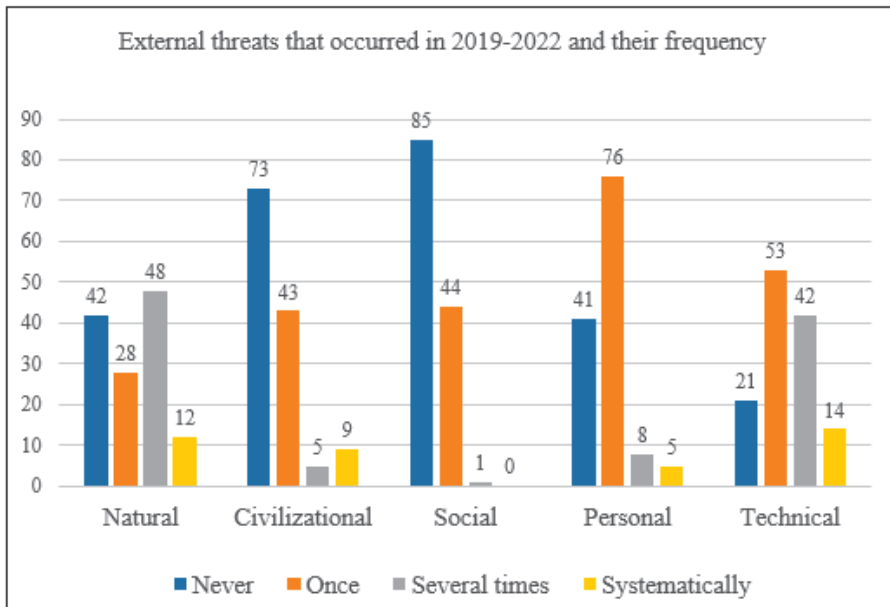


Fig. 1. External threats that occurred in 2019-2022 and their frequency

Source: Own elaboration based on respondents' answers

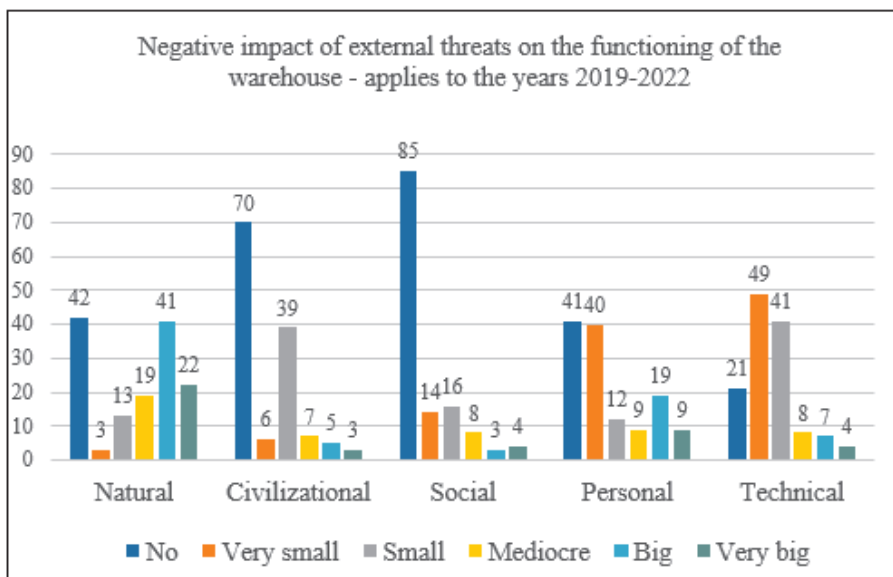


Fig. 2. Negative impact of external threats on the functioning of the warehouse - applies to the years 2019-2022

Source: Own elaboration based on respondents' answers

On the other hand, the threats to the warehouse economy that occurred “several times” and “systematically” concern:

- delivery delays - 90 cases (69.20%);
- improper completion - 63 cases (48.40%);
- complaints / returns of a large batch - 55 (42.30%) cases.

Table 2. Internal non-technical threats in the warehouse (quantitatively and %)

Frequency →	Never	Once	Several times	Systematically
Threats ↓				
Incorrect accounting	24/18.5	49/37.6	57/43.8	0/0.0
Improper picking	29/22.3	38/29.2	52/40.0	11/8.4
Theft of goods	77/59.2	21/16.1	32/24.6	0/0.0
Delivery delay	9/6.9	31/23.8	73/56.1	17/13.0
Complaints/returns of a large batch	11/8.4	64/49.2	47/36.1	8/6.1
Lack of financial liquidity	76/58.4	29/22.3	13/10	12/9.2
Loss of goods for shipment	83/63.8	32/22.3	15/11.5	0/0.0
Accidents at work	31/23.8	78/60	21/16.1	0/0.0
Loss of contract / interruption of the supply chain	44/33.8	48/36.9	29/22.3	9/6.9
Infectious diseases	41/31.5	39/30	44/33.8	9/6.9

Source: Own elaboration based on respondents' answers

Two of the threats mentioned above (delivery delays and improper completion) are the “effect” of organizational errors within the warehouse. The third is a consequence of the previous two. Therefore, warehouses wanting to improve customer service quality must necessarily improve the internal system in terms of eliminating these two negative phenomena. This can be done through two-way changes, which can be implemented independently of each other. First, improving the efficiency and effectiveness of the human factor (better use of it through appropriate personnel changes) and/or implementing instruments (tools) supporting warehouse policy, whose main goal will be to eliminate errors and better coordinate logistics activities undertaken in the warehouse. Such solutions include, among others, warehouse automation through the implementation of various IT systems improving the process of managing it.

The next issue concerns the assessment of the importance in the context of the negative impact of the above threats on the warehouse work. Table 3 shows which threats are least or most “significant” in the respondents’ opinion.

Table 3. Level of negative impact on warehouse operation in case of internal non-technical threats

Level of negative impact →	None	Very small	Small	Mediocre	Big	Very big
Threats ↓						
Incorrect accounting	23/17.6	41/31.5	16/12.3	29/22.3	17/13.0	4/3.0
Improper picking	31/23.8	33/25.3	17/13.0	14/10.7	29/20	6/4.6
Theft of goods	81/62.3	14/6.0	24/18.4	7/5.3	4/3.0	0/0.0
Delivery delay	3/2.3	47/20.4	9/4.6	41/31.5	22/16.9	8/6.1
Complaints/returns of a large batch	7/5.3	41/31.5	27/20.7	12/9.2	23/17.6	20/15.3
Lack of financial liquidity	67/51.5	23/17.6	14/10.7	11/8.4	9/6.9	6/5.3
Loss of goods for shipment	63/48.4	27/20.7	22/16.9	8/6.1	10/7.7	0/0.0
Accidents at work	19/14.6	56/43.0	21/16.1	4/3.0	23/17.6	7/5.3
Loss of contract / interruption of the supply chain	42/32.3	33/25.3	9/6.9	31/23.8	14/10.7	1/0.1
Infectious diseases	39/30.0	16/12.3	23/17.6	20/15.3	24/18.4	9/6.9

Source: Own elaboration based on respondents’ answers

Based on the data from Table 3, it can be stated that the level of negative impact on the warehouse operation in the situation of internal non-technical threats in the groups: “none”, “very small”, “small” is the lowest in the case of:

- loss of goods - 112 cases (86%);
- lack of financial liquidity - 104 cases (80%);
- inventory errors - 80 cases (61%).

On the other hand, when assessing the impact of threats in the groups “medium”, “large”, “very large”, it is the highest in situations:

- theft of goods - 71 cases (54%);
- infectious diseases - 57 cases (43%);
- complaints / returns of a large batch - 55 cases (42%).

As can be seen from the above, a serious problem in the assessment of the surveyed entities are the first two of them (theft and infectious diseases). This proves the importance of the “human factor”, which is an essential element of warehouse management - it can have both a positive and a negative impact on the broadly understood “effectiveness” of warehouse operation. On the one hand, it can decide on its development, on the other hand, it can pose a serious threat to this development.

Analysis of internal technical threats in the warehouse

The answers to the question asked in the survey what internal technical threats occurred in your warehouse in the last three years? clearly show that besides non-technical threats, there are others such as: failure of the IT system, flooding of the warehouse, fire in the warehouse, mechanical damage to goods, failure of internal transport means, failure of internal technical system (electrical, ventilation, etc.). As it follows from the survey, in the group of 6 technical threats (failure of IT system, flooding of warehouse, fire in warehouse, mechanical damage to goods, failure of internal transport means, failure of internal technical system) in warehouse management, which “never appeared” and “appeared once” are most favorably qualified:

- fire in warehouse - 120 cases (92.30%);
- flooding of warehouse - 110 cases (84.60%);
- mechanical damage to goods - 92 cases (70.80%).

On the other hand, threats that occurred “several times” and “systematically” concern:

- failure of IT system - 60 cases (46.10%);
- failure of internal transport means - 57 cases (43.80%);
- failure of internal technical system (electrical, ventilation, etc.) - 46 cases (35.40%).

Based on the data from the survey, it can be stated that the level of negative impact on warehouse operation in the situation of internal technical threats in groups: “none”, “very small”, “small” is lowest in case of:

- fire in warehouse - 130 cases (100%);
- flooding of warehouse - 122 cases (93.80%);
- mechanical damage to goods - 92 cases (70.80%).

On the other hand, when summarizing the impact of internal technical threats, summarily in three groups “medium”, “large”, “very large”, it turns out that the biggest negative impact on warehouse management, which managers (owners) are afraid of, concern failures:

- IT system - 71 cases (54.60%);
- internal transport means - 52 cases (40%);
- internal technical system (electrical, ventilation, etc.) - 40 cases (30.80%).

The analyzed results clearly confirmed that technical threats are related to the level of impact on warehouse management. The more often (less often) they occur, the greater (smaller) losses are, which is best exemplified by three threats: fire in warehouse, flooding of warehouse, mechanical damage to goods.

Analysis and evaluation of hazards classified into the second group, which included technical factors affecting the safety in warehouses. Use of technical systems affecting the safety of warehouse processes. The first question from this

scope was: „do you have technical systems in your warehouse and when were they implemented? The results are presented in Figure 3.

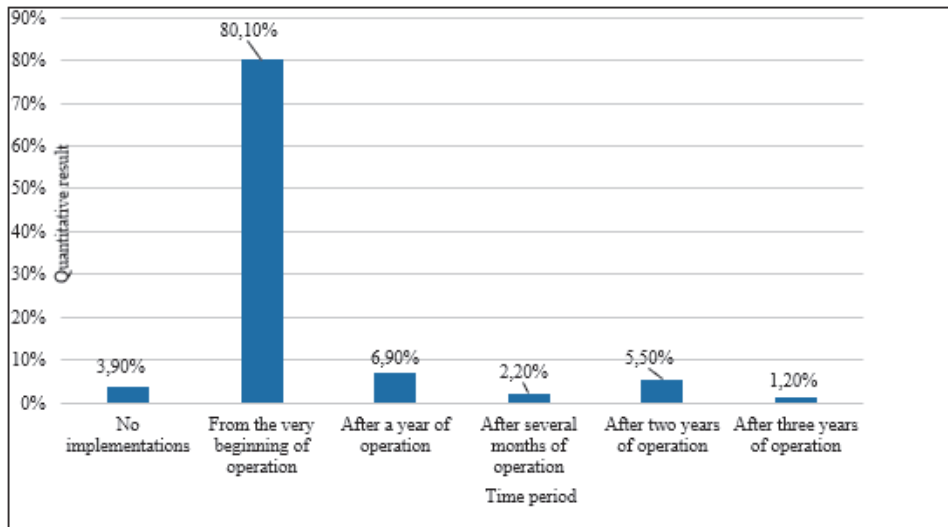


Fig. 3. Time of implementation (use) of technical systems in the surveyed warehouses

Source: Own elaboration based on respondents' answers

As shown in the summary, in more than 80% of the warehouses, devices and systems that affected the safety of logistics processes and the infrastructure used were implemented from the very beginning of their operation. This is probably related to the restrictive building regulations and the social awareness of the management (owners, investors) of the warehouses. Of course, the secondary issue is only the answer to the question whether these implementations are sufficient, i.e. whether they are able to prevent the occurring threats, since such occur. Here again, one can refer to the human factor, because one of the most serious sources of various threats is man, and the lack of appropriate solutions in this area (despite adequate infrastructure) may not bring the expected (positive) results.

The next question addressed to the respondents was: *which of the technical systems operate in the warehouse and how often do they undergo inspection in practice?* The choice concerned 12 systems and 6 cases of inspection dates. As shown by the analysis, in 130 warehouses, the most frequently installed technical systems included such as:

- hydrants and fire extinguishers, fire alarm systems and emergency (evacuation) exits - 100%;
- monitoring using burglary and robbery alarm systems - 97.70%;
- video monitoring (CCTV) - 90%;

- emergency power supply - 89%;
- acoustic signalers and smoke detectors - 87.70%;
- motion sensors - 83.90%;
- sprinkler installation - 83.10%;
- flaps and ventilation gates - 80.80%;
- gas detection systems - 75.40%.

The result of the analysis shows that technical solutions play a large role in warehouse security, which are used to improve security. In this study, an average of 75 - 100% of companies have applied such solutions. This is undoubtedly the result of existing regulations and the awareness of management staff in the context of improving security and eliminating existing threats. It should also be positively assessed that they care about the technical efficiency of the devices used, as evidenced by surveys in terms of frequency of their inspection. And so technical inspections were carried out in case of:

- video monitoring - 97.35%;
- smoke motion sensor - 94.80%;
- flaps and ventilation gates - 94.20%;
- hydrants and fire extinguishers - 96.90%;
- sprinkler installation - 95.40%;
- monitoring using burglary and robbery alarm systems - 100%;
- smoke detectors - 86.90%;
- acoustic signalers - 83.30%;
- emergency exits (evacuation) - which in total amounted to 88.40%;
- emergency power supply - 89.90%;
- gas detection system e.g. carbon dioxide, carbon monoxide - 86.70%;
- fire alarm system - which in total amounted to 81.30%

Generally, it should be stated that supervision over technical inspection of devices securing warehouse is proper, which is evidenced by assessments resulting from conducted research. However, it should be emphasized that approach of responsible persons to supervision over exploitation is diversified what is visible in research.

Discussion

In discussing the topic with various (both domestic and foreign) authors in the field of the research gaps identified, it should be stated that there are a number of similarities and differences. The similarities include:

The topic of warehouse safety is current and developing, both in theory and practice. Literature studies and own research show that the environment, both closer and further, is changing. Only a current assessment of procedures, people's behavior,

work culture allow to take appropriate tools and instruments influencing the safety culture in warehouse management. Current knowledge, including new technologies and research (survey, questionnaire, interviews) allow to protect not only people but also stored stocks ((Alhamami, Udup, 2020, pp. 291-294, Forcina, et al., 2024).

The topicality of the topic (in relation to people and stocks) resulting from the expansive development in terms of technical and functional (Sunol, 2023) [access: 10.06.2023]. Today's warehouses do not resemble those from a few years ago. Their scope of activity has expanded significantly, especially in the area of new technologies (Muha, Škerlič, Erčulj, 2020, pp. 321-333). Hence, the emergence of many different threats and the need to counteract them at the stage of their identification.

The diversity of threats to the security of warehouse economy, which are constantly changing, some disappear and others appear. This is undoubtedly the effect of a turbulent environment, which man has or does not have a direct influence on (Alhamami, Udup, 2020, pp. 291-294).

The constancy of three factors on which the security of the warehouse depends: technical equipment, organization and human factors. The need to improve technical and organizational equipment results from the need to perform more and more new tasks. Their multi-tasking character requires constant changes of an adaptive nature (Tikwayo Lihle, Mathaba Tabello, 2023) [access: 15.05.2023].

In relation to the human factor, it becomes necessary to constantly monitor the optimal level of security, taking into account ergonomics (Jang, Chen, 2013, pp. 681-686).

In the context of differences - the presented studies indicate that there are significant discrepancies in relation to the role of technical equipment in different types and classifications of warehouses both in Poland and in the world. In modern warehouses, the technical factor has become so important that it results in the implementation of the latest solutions in the field of Logistics 4.0 with full automation and robotization (Tikwayo Lihle, Mathaba Tabello, 2023) [access: 15.05.2023]. In Poland, this process is only in the initial phase of implementation, and it will take many years before it reaches a high level of advancement. Another difference concerns the human factor. It turns out that the level of security remains in close correlation with the awareness of the role that man plays in this process.

Conclusions

The warehouse is a basic link in the implementation of tasks within the supply chain. Without it, it is difficult to imagine the functioning of business processes related to supply, production/services, distribution. It should be remembered that all warehouses are exposed to various types of threats, which can be caused by human

or natural factors. The conducted own research contributed to the elimination of two research gaps, by:

- specifying external threats (among the five most common we have to deal with natural and technical threats), internal non-technical threats, internal technical threats, which may appear in warehouse management,
- assessing and recommending technical solutions affecting the functioning of warehouse management in the context of security.

Not insignificant for the article is the identification of the research problem, which concerned the degree of functioning of technical and non-technical systems affecting warehouse management in situations of a wide range of threats. The results of the research presented in this article are useful in practice, as they allow to identify threats in the context of their negative impact on logistic processes, taking into account technical solutions. Based on these studies, a number of important conclusions can be drawn that confirm the validity of the assumed hypothesis. First, internal threats to warehouses can be divided into non-technical and technical. Among the former, the human factor is crucial, which directly affects such factors as: proper picking, theft or infectious diseases. Hence, it is necessary to eliminate such threats by taking appropriate corrective and awareness-raising actions for the staff about their importance in the whole process of ensuring security in warehouse management. Among the latter, three types of most common ones were identified: fire in the warehouse, flooding of the warehouse, mechanical damage to the goods, which directly affects the generated losses in the warehouse. Second, technical security systems in warehouses were identified. It turns out that the availability and equipment of warehouses are adequate. This is due to existing regulations and (probably) penalties for lack of necessary equipment. Therefore, the awareness of managers in this area should be perceived in a dual context - concerning legal knowledge and the need to ensure safety and eliminate various hazards in warehouses (both in relation to people and goods). Thirdly, the systematicity of inspections and necessary repairs indicates awareness regarding technical equipment with necessary devices. In this respect, all assessments were made at a "good" or "very good" level. Doubts are raised by those issues (supervision and operation) that relate to the human factor. As the research shows - they are very diverse.

BIBLIOGRAPHY

- [1] Alhamami, H.K., Udup P.K., 2020. Warehouse safety and security. *Global Scientific Journals*, 8, (7).
- [2] Balan, I.L., Cioca, L-I., Torrett,a V.,Talamona, L., 2016. Warehouse Threats and Loss Prevention Management in Case of Fire, *Procedia Technology*, 22.
- [3] Brown, R., 2022. 6 potential threats to warehouse facilities. https://thebossmagazine-com.translate.google/potential-threats-to-warehouse-facilities/?_x_tr_sl=en&_x_tr_tl=pl&_x_tr_hl=pl&_x_tr_pto=sc, [01 May 2023].

- [4] Chojnacki, T., (2019), Shaping of functional and spatial warehouses, including architectural and logistic aspects, *Systemy Logistyczne Wojsk* nr 50/2019, 19-31.
- [5] de Koster, R.B.M., Stam, D., Balk, B.M., 2011. Document details - Accidents happen: The influence of safety-specific transformational leadership, safety consciousness, and hazard reducing systems on warehouse accidents. *Journal of Operations Management*, 29 (7-8).
- [6] de Vries, J., de Koster R., Stam D., 2016. Safety does not happen by accident: antecedents to a safer warehouse. *Production and operations by accident: antecedents to a safer warehouse*, 25, (8).
- [7] Ferrer, B.S., 2023. Warehouse indicators in the supply chain. https://www-netlogistik-com.translate.google/en/blog/warehouse-indicators?_x_tr_sl=en&_x_tr_tl=pl&_x_tr_hl=pl&_x_tr_pto=sc, [08 February 2023].
- [8] Forcina, A., Falcone D., 2021. The role of Industry 4.0 enabling technologies for safety management: A systematic literature review. *Procedia Computer Science*, DOI: 10.1016/j.procs.2021.01.260.
- [9] Forcina, A., Silvestri, L., De Felice, F., Falcone, D. 2024. Exploring Industry 4.0 technologies to improve manufacturing enterprise safety management: A TOPSIS-based decision support system and real case study, Elsevier, 169, <https://doi.org/10.1016/j.ssci.2023.106351>.
- [10] Hofstra N., Petkova B., Dullaert W., Reniers G., de Leeuw S., 2018. Assessing and facilitating warehouse safety. Elsevier, 8, <https://doi.org/10.1016/j.ssci.2018.02.010>.
- [11] Jang, R-L., Chen, A-Ch., 2013. Hazards and Risks Associated with Warehouse Workers: A field study, *Proceedings of the Institute of Industrial Engineers Asian Conference 2013*, Tajpej, 18.07.2013.
- [12] Larco, J.A., de Koster, R., Roodbergen, K.J., Dul, J., 2013. Managing warehouse efficiency and worker discomfort through enhanced storage assignment decisions. *International Journal of Production Research*, 55.
- [13] Muha, R., Škerlić, S., Erčulj, V., 2020. The Importance of Risk Management for the Introduction of Modern Warehouse Technologie, *Promet – Traffic & Transportation*, 32, (3).
- [14] Schuetz, M., 2022. Everything You Need to Know About Warehouse Security. <https://www.getkisi.com/blog/everything-you-need-to-know-about-warehouse-security>, [20 July 2023].
- [15] Sienkiewicz, P., 2003. Teoria i inżynieria systemów. In: P. Sienkiewicz, *Inżynieria systemów bezpieczeństwa*. Warszawa, PWE, 9.
- [16] Sowa, M., 2018, Threats to health and safety at work when completing a warehouse process. *European Journal of Service Management* 27/1, (3).
- [17] Staniecka, E., 2021. Selected Aspects of Supply Chain Security Management, *Military Logistics System*, 54.
- [18] Sunol, H., 2023. 5 Common Warehouse Technology Issues & Their Real Causes. https://articles-cyberg-com.translate.google/logistics-technology-5-common-issues-real-causes/?_x_tr_sl=en&_x_tr_tl=pl&_x_tr_hl=pl&_x_tr_pto=sc, [10 June 2023].
- [19] Szymonik, A., Smal, T., 2019. Safety Modeling in Military Warehouse, *Management*. International Conference on Military Technologies. Brno, 30-31.05.2019.
- [20] Szymonik, A., Stanisławski, R., 2023. Supply Chain Security. How to Support Safety and Reduce Risk in Your Supply Chain Process. New York: Routledge /Taylor & Francis Group, 5-10.
- [21] Tikwayo, Lihle, N., Mathaba Tabetlo, N.D., 2023. Applications of Industry 4.0 Technologies in Warehouse Management: A Systematic Literature Review, https://www-mdpi-com.translate.google/2305-6290/7/2/24?_x_tr_sl=en&_x_tr_tl=pl&_x_tr_hl=pl&_x_tr_pto=sc, [15 May 2023].

- [22] Whiting, G., 2023. 10 quick actions you can take to improve warehouse security. https://www-explorewms-com.translate.google/actions-for-improved-warehouse-security.html?_x_tr_sl=en&_x_tr_tl=pl&_x_tr_hl=pl&_x_tr_pto=sc, [21 July 2023].
- [23] Zhang, Y., 2022. Warehouse Management System Based on RFID and Internet of Things Technology. 2nd International Conference on Networking, Communications and Information Technology. Manchester, United Kingdom, 26-27.12.2022.