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Pneumatic tube systems in healthcare logistics: Case Study on operational efficiency and development requirements in Hungary

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Abstract: Last-Mile Delivery, the final step in the logistics chain, has become critical but also faces challenges in both urban and rural areas. One potential solution is the use of pneumatic tube systems, already implemented in some countries for specific purposes. This investigation examines the operation of a pneumatic tube system in a Hungarian hospital. The aim of the publication is to investigate how pneumatic tube systems can enhance the efficiency of Last-Mile Delivery, with a particular focus on Hungarian healthcare institutions. The objective is to identify potential areas for development and explore broader applications of these systems beyond their current use.
The research focused on a pneumatic tube system operating within a Hungarian healthcare institution. Data were collected through a questionnaire-based survey and in-depth interviews with system users. The survey explored user experiences, expectations, and suggestions for improvement. The questionnaire results indicate that while pneumatic tube systems offer several advantages, several areas require improvement. Respondents emphasized the importance of speed and reliability and highlighted the need for technical modernization. The feedback suggests that, beyond the healthcare sector, pneumatic tube technology may have potential applications in other logistics fields.
Pneumatic tube systems represent a viable alternative for addressing increased Last-Mile Delivery demands, especially in closed or specialized environments such as healthcare institutions. The research demonstrated that, with appropriate development and adaptation, these systems could be extended beyond their traditional use and applied in new logistical contexts.

Keywords: pneumatic tube system, supply chain, healthcare logistics.

JEL Classification: G21, L26, O16

1 Introduction

Last-mile delivery is one of the most complex and costly stages of the logistics process, which has a significant impact on the efficiency of the entire supply chain (Bartucz and Süle, 2023). The dynamic growth of e-commerce and rapidly changing consumer expectations – particularly the demand for short delivery times and reliable delivery – are forcing logistics providers to innovate continuously (DHL Group, 2019). However, traditional delivery methods face several obstacles: traffic congestion in urban areas, time lost in loading operations, and the need to constantly re-plan delivery routes, all of which reduce efficiency (Izadkhah et al., 2022; Reiffer et al., 2023).
The operational characteristics of the system – short delivery times, automated processes and independence from human resources – enable increased logistical efficiency (Balassa et al., 2023), especially in urban

environments where traffic and infrastructure constraints significantly slow down traditional delivery processes (Dieter et al., 2023; Wei et al., 2024).
The aim of this study is to examine the operating conditions and practical applicability of pneumatic tube systems in the context of Last-mile logistics. During the research, primary data was collected from a pneumatic tube system in a Hungarian hospital, including a questionnaire survey of staff who use the system daily. Research questions related to the topic:

- How can the pneumatic tube system contribute to increasing the efficiency of last-mile delivery?
- What are the advantages of the pneumatic tube system over traditional delivery methods?

The aim of the study is to examine the operating conditions and practical applicability of pneumatic tube systems in the context of last-mile logistics. The empirical research is based on the pneumatic tube system at a Hungarian hospital, supplemented by a questionnaire survey of employees who use the system daily. The main questions of the research focus on how the pneumatic tube system increases the efficiency of last-mile delivery and on the advantages it offers over traditional transport solutions. The research also aims to identify operational problems in the existing system and opportunities for improvement. It can be assumed that a pneumatic tube system installed in a specific area for a specific purpose can provide an effective solution to the growing demand for internal and last-mile delivery. The results contribute to expanding the literature on internal logistics systems while ensuring a clear separation between empirical observations and the generalizable conclusions drawn from them.

2 Literature review

Digitalization has a significant impact on sustainability, as it brings both environmental benefits and new challenges (Kunkel and Tyfield, 2021; Rejeb et al., 2025). Digital technologies contribute to increasing energy efficiency and reducing greenhouse gas emissions, for example, through more efficient data center operations and the use of renewable energy sources (Bosona, 2020; Rejeb et al., 2025). Teleworking, intelligent transport systems, and smart city solutions reduce transport demand, thereby reducing environmental impact (Rejeb et al., 2025).
In addition, digitalization increases transparency in supply chains, promotes more efficient resource use, and supports sustainable logistics processes (Bartucz et al., 2023). At the same time, the use of digital technologies also carries environmental and social risks, such as increased electronic waste, high energy consumption, and growing digital inequalities, which is why an appropriate regulatory framework is needed to maximize the positive effects (Kunkel and Tyfield, 2021). The pneumatic tube system, as an automated and digitized logistics solution, enables faster internal hospital transport and is a good example of the impact of digitization on service and logistics systems.

2.1 The positive and negative role of digitalization in sustainable operations

Digitalization contributes to sustainability by reducing energy consumption, promoting online billing and paperless solutions, and reducing transportation through remote work and online education (Kunkel and Tyfield, 2021). Increasing the transparency of supply chains reduces waste and unnecessary transport, promoting sustainable procurement and logistics (Thomas et al., 2022a). Digital platforms for the sharing economy can reduce urban traffic and transport emissions (Silva et al., 2023), while online marketplaces and apps increase access to sustainable products and services (Salvi et al., 2021).

In addition, digital technologies support environmental data monitoring and improvements in resource efficiency, and promote corporate transparency, encouraging sustainable operations (Thomas et al., 2022b). At the same time, it is essential to adopt ethical, sustainable digitalization practices to minimize negative environmental impacts and data protection risks.
The growth of online commerce has placed a significant burden on supply chains, as increased parcel traffic has resulted in more delivery vehicles and shipping delays (Correia et al., 2021). The burden has been further exacerbated by an increase in returns, particularly during the COVID-19 pandemic but still substantial today (Almelhem et al., 2023). Overall, e-commerce has promoted digitalization but has had both positive and negative effects on supply chains and urban traffic (Alsakhen, I., Buics, L., & Süle, E., 2024).

2.2 Last-Mile Delivery

Customers expect to receive their products quickly, on time, and at a reasonable price (Süle, 2009). The final element of the delivery process is Last-Mile Delivery, which covers the last phase of the delivery process, namely the transport from shops or logistics centres to the customer's door (Sós et al., 2023). The key elements of Last-Mile Delivery are efficiency and speed (Bartucz et al., 2023), meaning that delivery couriers want to perform their tasks as quickly and efficiently as possible (Földesi et al., 2011; Süle, 2013). Last-mile delivery places a significant burden on the supply chain, so it is important to consider, for example, how pneumatic tube systems can be used in a city (Smart Kalasatama 2015).

2.3 Theoretical Framework: Pneumatic Tube System Evaluation

The performance of a pneumatic tube system (Garg & Dewan, 2022) in last-mile and internal logistics processes can be interpreted along three main dimensions: efficiency, reliability, and risk.

<u>Efficiency</u>
Efficiency measures the extent to which the system improves the use of time, labor, and resources compared to traditional manual transportation (Isken & Littig, 2002). Key elements:

- Reduction in transportation time
- Reduction in labor requirements
- Reduction in lead times
- Reduction in internal traffic

Connection to last-mile logistics:
The Pneumatic Tube System operates as a micro-last-mile solution in a closed environment where time-critical delivery (e.g., samples, pharmaceuticals) is key (Peak, 2002).

<u>Reliability (Reliability)</u>
Reliability describes how stable, error-free, and predictable the system operates in daily use (Koroglu et al., 2016; Lazarov et al., 2025). Key elements:

- Severity of failures
- Delivery accuracy
- System availability
- User satisfaction

Healthcare context:
Reliability is critical in hospital logistics, as delays can directly impact the quality of care.

Risk

The risk dimension focuses on identifying technological, operational, and safety issues (ISO, 2023; Yu et al., 2025). Key elements:

- Risk of system downtime
- Injury or package damage
- Infection control and hygiene risks
- Data and process governance issues
- Sustainability relationship:
- Misoperation can increase energy consumption, waste generation, and the need for re-delivery.

The performance of a pneumatic tube system can be interpreted along three interrelated dimensions: efficiency, reliability, and operational risks. The system perfectly guarantees a last-mile solution in an institutional environment if it is able to simultaneously reduce lead times and resource usage, as well as ensure stable operation and minimize operational and security risks.

2.4 Pneumatic tube systems

The increase in the volume of Last-mile deliveries also poses a challenge for logistics professionals, as the delivery of large numbers of parcels strains the supply chain. One possible solution is the development and use of a pneumatic tube system, which has already been addressed in Finland as part of the Smart City program (Smart Kalasatama, 2015).
We conducted keyword searches across Scopus, ScienceDirect, and Web of Science using the term "pneumatic tube system" to identify publications on the subject and determine the total number. The results of the search are shown in Table 1.

Table 1: Search results on October 17, 2024

Results on 17/10/2024		ScienceDirect	Scopus	Web of Science
"pneumatic tube system"		472	607	198
"pneumatic tube system"	Last 5 years (2020-2025)	138	243	63

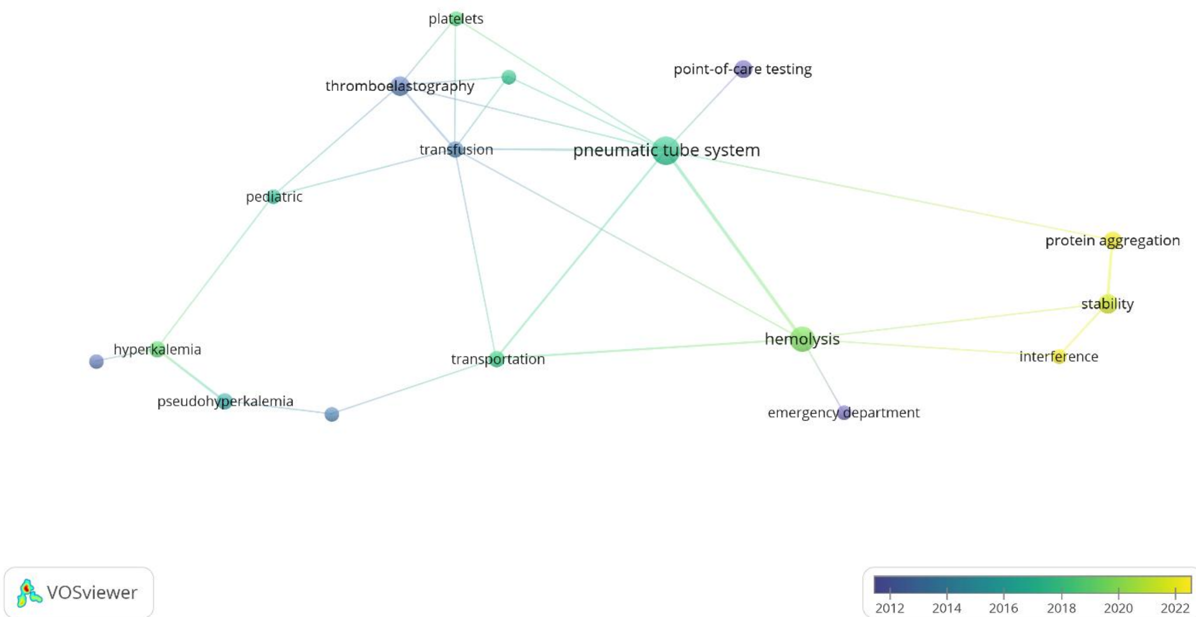

Fig. 1. Visualization based on the Science Direct database. Created on October 17, 2024. Minimum number of occurrences: 4 (Source: own compilation)

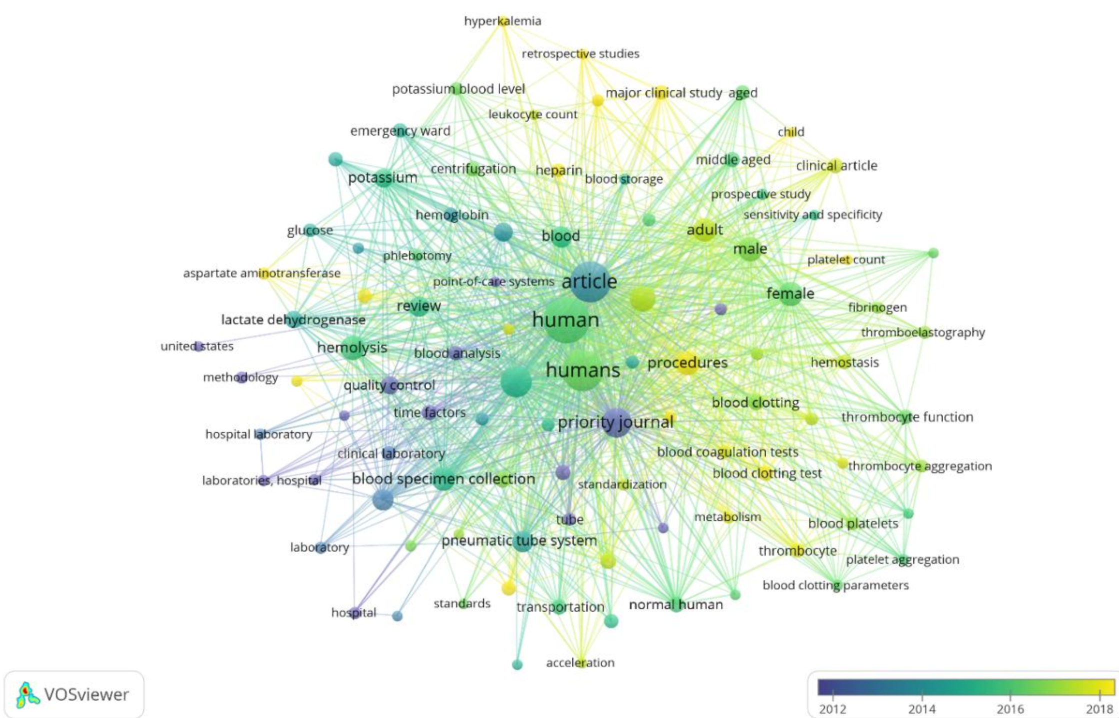

Fig. 2. Visualization based on the Scopus database. Minimum number of occurrences: 4. Created on October 17, 2024. (Source: own compilation)

Figure 1 shows that in 2018, the keyword "transportation" appeared alongside "pneumatic tube system" in relation to this topic, indicating that, even then, research had already raised the possibility of using pneumatic

tube systems for last-mile delivery. Most of the keywords are related to healthcare, suggesting that the investigation of pneumatic tube systems in healthcare institutions was considered relevant research.
Figure 2, based on the keywords "pneumatic tube system" in the Scopus database, shows that in 2015, in addition to the term "pneumatic tube system," the term "transportation," i.e., urban freight transport, was also used to search for suitable modes of transport. Here, too, a number of keywords related to healthcare emerge. Both figures show the keywords "blood" and "hemolysis," indicating that several publications have addressed damage to blood during pneumatic tube transport. This topic is important because the safety of goods transport is of paramount importance in all pneumatic tube systems.

3 Methodology

The research methodology consisted of in-depth interviews and questionnaires. To learn about the operation of pneumatic tube systems, we conducted research at a hospital in Hungary. The institution did not consent to the publication of its name, so we will not mention it in this publication. For the research, we prepared a questionnaire that asked about the operation of the pneumatic tube system and experiences arising from its daily use. The institution's management expressly requested that the questionnaire be as short and quick to complete as possible, given that healthcare staff are very busy. This was taken into account when compiling the questions
During the questionnaire, questions were asked about the experiences of everyday use of the pneumatic tube system, how often, and for which products it can be used effectively. In addition, questions were asked about the type and frequency of failures experienced during use. At the end of the questionnaire, we asked for suggestions regarding the pneumatic tube system in free-text format, which were categorized and summarized. However, in addition to completing the questionnaire, we were able to interview two people, so we also received answers to specific questions or those that would have required long answers, which were not included in the questionnaire. During the in-depth interviews, two experts were interviewed. One expert works in the technical department and troubleshoots the pneumatic tube system. The other expert is the head of the central laboratory, the "biggest user" of the pneumatic tube system, as blood samples are delivered to the laboratory via it. The questionnaire was completed by 48 hospital professionals. Their free-text responses were analyzed by categorizing the suggestions according to topic and summarizing them.

3.1 Information about the operation of pneumatic tube systems based on the interviews

First, will describe the operation of the pneumatic tube system and the associated capsule The pneumatic tube system enables the efficient, flexible transport of blood samples, other laboratory samples, medicines, infusions, and devices in hospitals.

The central laboratory of the healthcare institution under investigation has two stations and two "branches," one for the emergency room and one for the general laboratory. There are 44 stations available throughout the hospital in various departments. The emergency "branch" is directly connected to the laboratory so that the capsules arrive as quickly as possible, as separate handling and timely processing of samples is essential for emergency care.

The display on the machine connected to the pneumatic tube system shows only minimal information, such as whether it is in "normal" or "error" mode, and whether a capsule is currently being received or sent ("receiving" and "sending"). When a shipment arrives, it lights up blue and "locks the system," meaning that the machine's door cannot be opened at that time. The arrival can be heard by the staff with the naked ear.

The departments theoretically organize the samples in an orderly fashion, but sometimes they put them in a bag and then place the bag into the capsules in a disorderly manner. The samples are accompanied by a form containing the patient's data and the test type to be performed. Sometimes more than one tube is required for a test, in which case they are usually tied together with rubber bands. If they are not tied together, they arrive in bulk and have to be sorted to determine which document belongs to which sample.
When they arrive in bulk, the blood collection tubes are often damaged, and their contents spill out, destroying the sample (e.g., blood or urine) and contaminating the documentation and other sample collection tubes. This is a problem because, in such cases, the sample must be taken again from the patient, which is often difficult, especially in children.
Organized delivery also helps the central laboratory, because if they have a long list, the blood collection tubes tied together are easy to identify on the delivery note.
Reviewing samples arriving by tube mail and matching them with documentation takes extra time for the laboratory. However, the pneumatic tube system benefits the various departments by saving time on manual deliveries and is also advantageous from a security standpoint, as employees do not have to walk through unlit corridors at night to deliver samples to the central laboratory.

3.2 Troubleshooting process

The operation of the pneumatic tube system is centrally monitored by the maintenance company. The pneumatic tube system is tracked using software. In the event of a fault, the software is first used to identify the problem, and on-site troubleshooting is then performed. Two types of errors can occur:

- The capsule gets stuck in the tube.
- It arrives at another station.

The laboratory knows that the capsule is stuck in the tube or that the samples from a given department have arrived at another location when the sending department calls to say that they have not yet received the results. The machines connected to the pneumatic tube system do not provide feedback on whether the capsule has arrived at its destination. If they notice a capsule stuck in the pneumatic tube system, they have to call the operator, who then switches back to manual delivery.

4 Results

We prepared a questionnaire about the operation of the pneumatic tube system. Forty-eight people completed the questionnaire, and in this chapter, we will present the answers to each question.

What types of packages are transported using the pneumatic tube system? (Multiple answers possible) Please rate your satisfaction on the following scale, where 1 is 'Not at all satisfied', and 6 is 'Completely satisfied'. - 48 responses

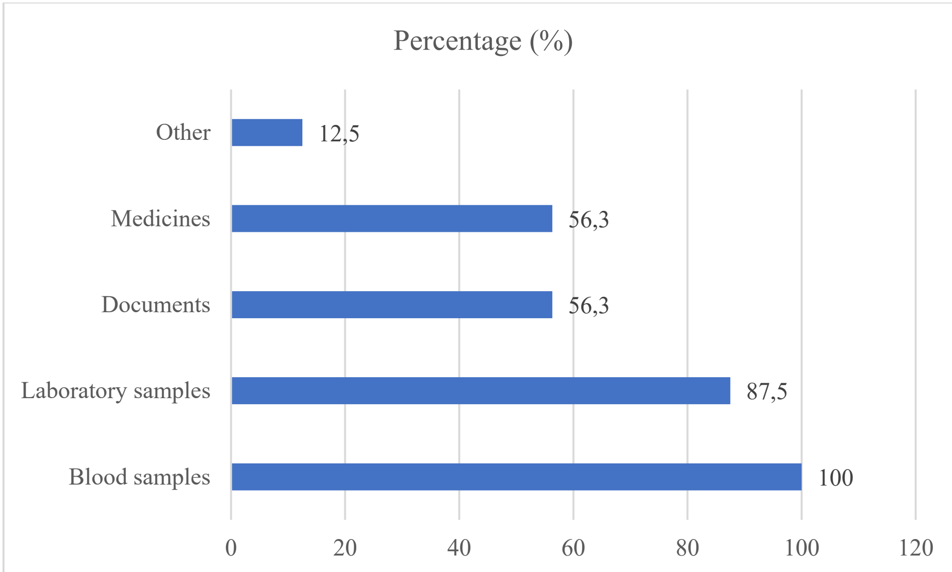

Figure 3: Types of packages transported using the pneumatic tube system (Source: own compilation)

Figure 3 shows the types of packages transported by the pneumatic tube system, providing the following information: Blood samples: 100% (48 responses), Laboratory samples: 87.5% (42 responses), Documents: 56.3% (27 responses), Medicines: 56.3% (27 responses), Other: 12.5% (6 responses). Based on this, it can be seen that the pneumatic tube system is most often used to transport blood samples and laboratory samples, while documents and medicines are also sent relatively frequently in this way.

How often is the pneumatic tube system used in a day? - 48 responses

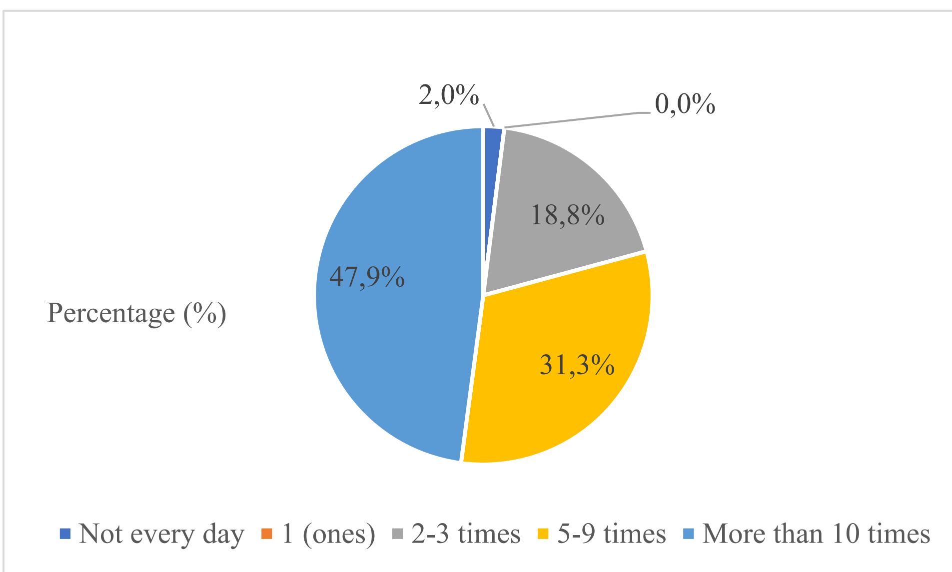

Figure 4: Frequency of use of the pneumatic tube system (Source: own compilation)

Figure 4 shows that almost half (47.9%) of pneumatic tube system users use it more than 10 times a day, and 31.3% use it 5-9 times a day. Based on this, it can be concluded that the capacity of the pneumatic tube system is fully utilized.

How reliable is the pneumatic tube system in the hospital?
Please rate your satisfaction on the following scale, where 1 is 'Not at all satisfied' and 6 is 'Completely satisfied'. - 48 responses

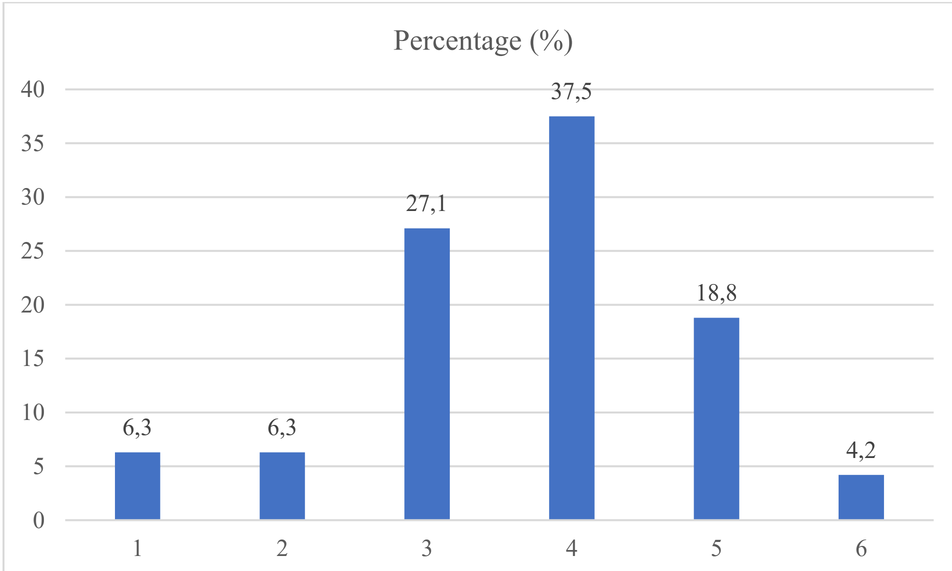

Figure 5: Reliability of the pneumatic tube system (Source: own compilation)

The figure assesses the reliability of the hospital's pneumatic tube system on a scale of 1 to 6. Most respondents gave a rating of 4 (37.5%, 18 responses), indicating that the system is considered reliable. The other significant portion of responses received ratings of 3 (27.1% - 13 responses) and 5 (18.8% - 9 responses), indicating moderate to good reliability. Fewer respondents rated the system significantly, with a score of 1 (6.3% - 3 responses) or 6 (4.2% - 2 responses). Overall, Figure 5 shows that more than half of the respondents consider the system to be reliable.

Have there been any errors or malfunctions? - 48 responses

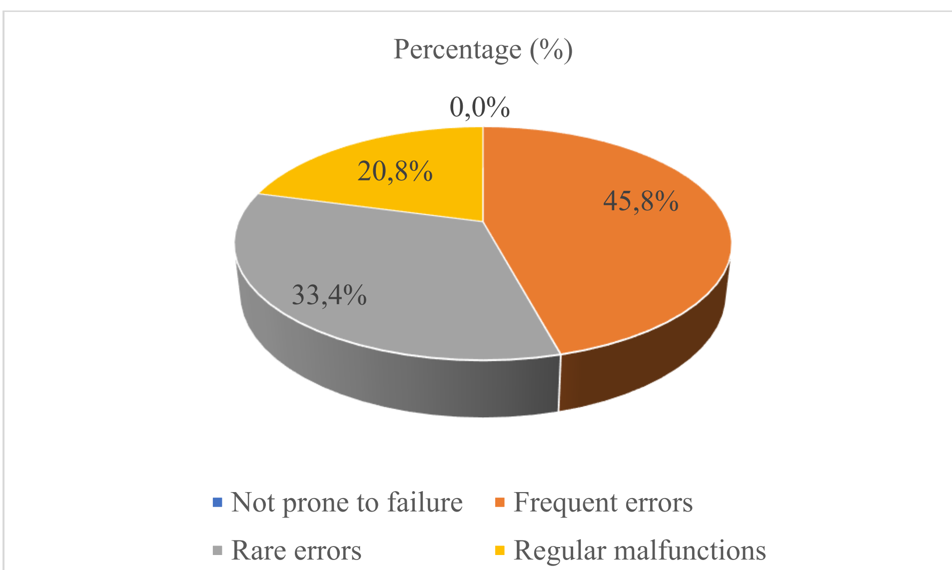

Figure 6: Reliability of the pneumatic tube system (Source: own compilation)

The figure shows that 45.8% of respondents believe that errors occur frequently in the pneumatic tube system, while 33.3% say that malfunctions occur rarely but do occur. According to 20.8% of respondents, the system malfunctions regularly, suggesting a significant reliability issue. This means that two-thirds of users experience frequent malfunctions. This was confirmed during the interview, but we were also informed that the system operator is currently being replaced and that regular maintenance may be a solution to the frequent malfunctions.

How fast does the pneumatic tube system operate?
Please rate your satisfaction on the following scale, where 1 is 'Not at all satisfied,' and 6 is 'Completely satisfied. ' - 48 responses

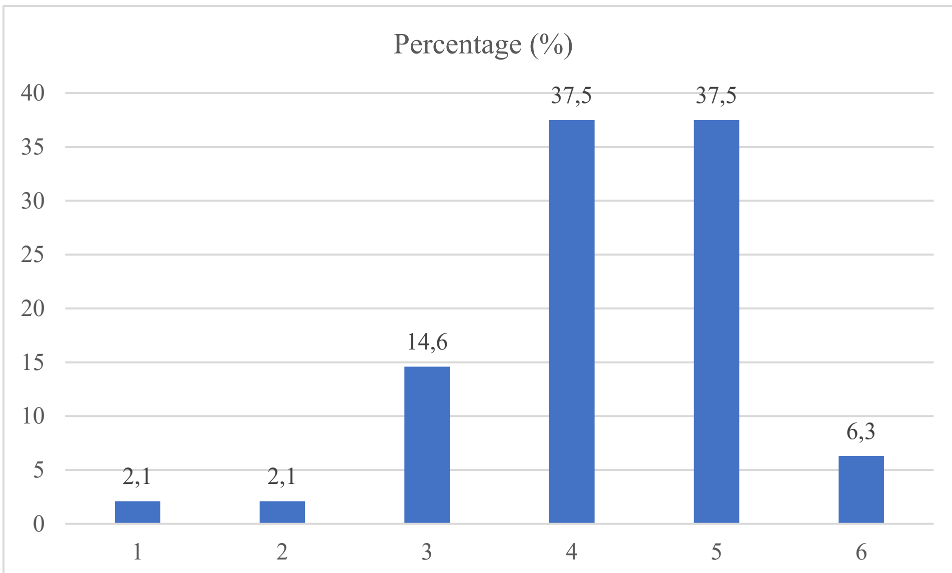

Figure 7: Speed of the pneumatic tube system (Source: own compilation)

According to Figure 7, respondents are largely satisfied with the pneumatic tube system's speed, with 75% rating it 4 or 5 on a scale of 1 to 6. Based on this, we can conclude that the system itself may be a good option, but the occasional faults and incidents need to be addressed.

Is there a tracking system for packages? - 48 responses

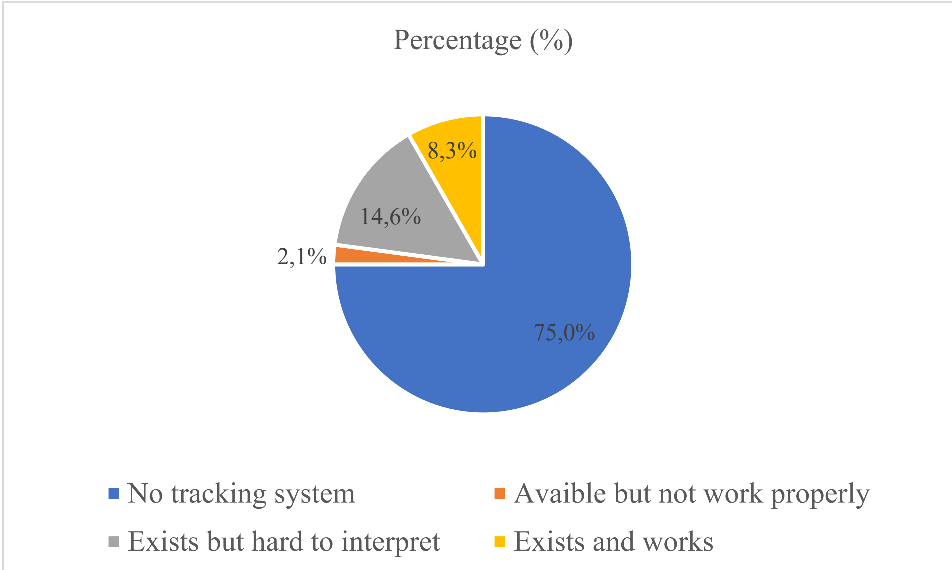

Figure 8: Trackability of the pneumatic tube system (Source: own compilation)

According to the diagram, 75% of respondents said there is no tracking system for packages, while 14.6% said there is, but the data is difficult to interpret. Only 8.3% indicated that such a system exists and works properly. From the interview, it was learned that the tracking system referenced in the responses is linked to the system operator, meaning the information is not directly available; it is accessible only in the event of a problem, when they are contacted by phone or email. In other words, the tracking system is only available centrally at the operator's premises, and the location and cause of the malfunction cannot be viewed individually.

How satisfied are hospital staff with the pneumatic tube system?
Please rate your satisfaction on the following scale, where 1 is 'Not at all satisfied,' and 6 is 'Completely satisfied. - 48 responses

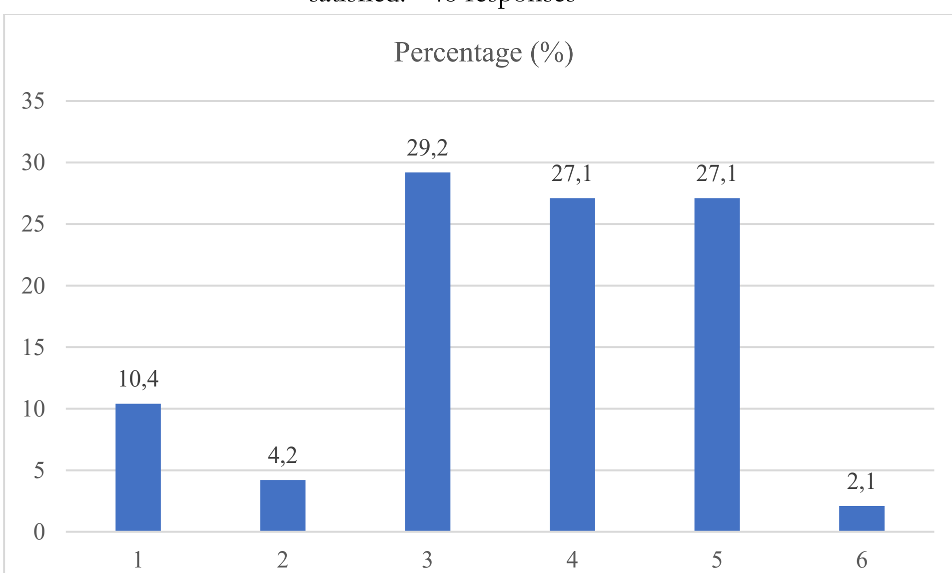

Figure 9: Satisfaction (Source: own compilation)

According to the diagram, most respondents (29.2%) are moderately satisfied with the pneumatic tube system (rating of 3), while 27.1% are highly satisfied (ratings of 4 and 5 also show this). Only 2.1% were completely satisfied, and 10.4% were not satisfied with the system at all. Overall, slightly more than half of users are satisfied with the system's operation.

Have you ever had a problem with damaged packages when using the pneumatic tube system? - 48 responses

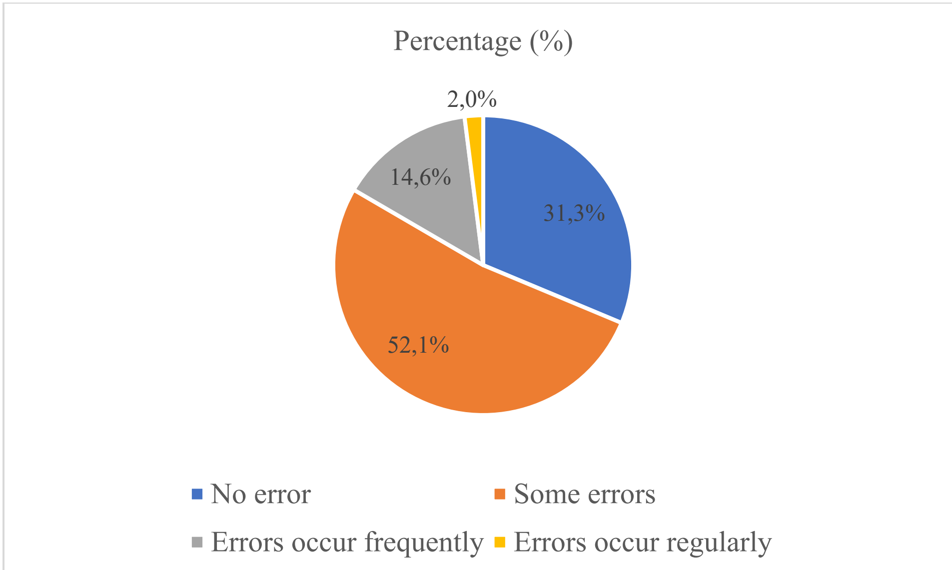

Figure 10: Question regarding damaged packages (Source: own compilation)

According to the diagram, 52.1% of respondents reported sometimes encountering problems with the pneumatic tube system, while 31.3% reported no problems. At the same time, 14.6% frequently encountered problems, and only a small percentage reported regular problems.
Based on the questionnaire analysis, the majority of respondents are satisfied with the system overall, but there are some operational flaws in the pneumatic tube system. These can be seen as areas for improvement, which, if implemented, could lead to even greater satisfaction and efficiency.

5 Discussion

The pneumatic tube system offers numerous advantages in transportation but can also pose several challenges (Turkowski and Szudarek, 2019). The operation of a pneumatic tube system requires consideration of various factors, which are detailed below:

5.1 Financial Aspects:

- Installation Costs: The installation of a pneumatic tube system can involve high initial costs, including the manufacturing and installation of tubes, as well as necessary infrastructural work.
- Maintenance Costs: The system requires regular maintenance during its operation, such as cleaning and repairing the tubes. These expenses can be significant over the long term.
- Operating Costs: The operation of the pneumatic tube system will require energy sources, such as electricity or other fuels, which contribute to the system’s operating costs.

- Security Costs: Ensuring and maintaining the safe operation of the system entails additional costs, such as the development and upkeep of adequate security systems.

5.2 Infrastructure Costs:

- Infrastructure Development: The implementation of the pneumatic tube system may require the transformation or creation of new infrastructure, including the construction of ducts within buildings.
- Permitting and Legal Costs: Installing and operating the pneumatic tube system may incur various permitting and legal costs, such as building permits, environmental approvals, etc.
- Experts and Expertise: Designing and implementing the system requires professionals and technical expertise, which also adds to the overall cost.

5.3 Technological Developments:

During infrastructure development, it is essential to consider technological advancements that can improve the system's efficiency and safety, though these also entail additional costs (Howgego and Roe, 1998).

- Tube System Installation: This includes building tunnels or conduits in which the system is placed.
- Air Blower Equipment: Costs related to the equipment that ensures air flow in the system.
- Installation Labour and Equipment Costs: Includes labour for infrastructural work and system installation, as well as procurement of necessary machinery and tools.
- Permitting Costs: Legal and regulatory permissions required for initiating and executing the project.
- Maintenance and Operational Costs: Regular inspections, maintenance, and repairs of both the tubes and the air blower systems.
- Energy Consumption: Cost of the energy needed for operating air blower equipment.
- Personnel Costs: Costs associated with the operation and supervision of the system.
- Sizing Considerations: The diameter and capacity of the tubes should match the volume and nature of the transported goods.
- Packaging Standardization: Standardizing the packaging of items transported through the pneumatic tube system is essential for efficient operation.
- Fault Management: The system should be designed to minimize damage or loss during transportation.
- Unexpected Costs: Unexpected problems or repair needs must be quickly addressed to ensure continuous service.

All these factors must be thoroughly considered during the planning and installation of the pneumatic tube system to ensure its economic viability and long-term sustainability. These costs can vary significantly depending on the project's size, the complexity of the infrastructure, and the specific characteristics of the area. Therefore, all budget-related factors should be carefully weighed during the planning phase (Desai et al., 2023).

5.4 Development Opportunities for the Pneumatic Tube System

At the end of the questionnaire, we offered users of the pneumatic tube system the opportunity to make free-text suggestions for improvement. Based on the analysis of the questionnaire, identified development opportunities, and conducted interviews, we determined potential improvements that could enhance and support the operation of the system:

- Data-Driven Decision Support and Analysis Tools: By collecting data on the operation of the pneumatic tube system, statistical analysis could be performed on successful and failed deliveries. These insights could help optimize development and accurately plan the system's capacity (Hódosi et al., 2023).

Additionally, departments should be provided with software to track capsules. This would allow visibility of who sent it, whether it arrived, and if not, where and when it got stuck. This is crucial for sample and patient safety. For the hospital, the most important thing is that the patient receives the sample in time. If a capsule remains stuck for 4–5 hours, the sample inside may no longer be analyzable or only to a very limited extent.
It would be essential to see which department is expecting a sample and whether it is still usable after removal if it gets stuck.

- Integration of Smart Systems for Error Handling: The system could automatically detect malfunctions and immediately report breakdowns to a central error reporting platform—not only via SMS to the maintenance team but also to the relevant hospital departments so that they can prepare for delays.
- Dynamic Capacity Expansion: On days or during periods of high traffic, the system could automatically allow for multiple capsules to be sent simultaneously, and algorithms could optimize capsule routes to avoid collisions or congestion.
- Expansion of Training Activities: Training on how to use the system, seal samples, and properly place them in capsules. I was informed that the laboratory staff had already provided training, including pictures and posters about correct capsule use, especially to the emergency department. The goal was to ensure as many samples as possible could be processed effectively. This training could be extended to other departments as well.
- Special Handling of Infectious Samples: Specially developed hermetically sealed capsules should be provided for infectious materials, following specific safety protocols. This would help minimize the risk of contamination of the tube system.
- Scheduled Maintenance and Disinfection of Capsules: Regular cleaning of capsules is essential, especially since, in some cases, samples may leak.

In addition to regular maintenance and disinfection, integrating new disinfection modules into the system could further enhance safety and hygiene, particularly for sensitive sample transport.

- Improving Energy Efficiency and Noise Reduction: The system should be developed with energy-efficient solutions to reduce operational costs. Moreover, reducing the system's noise levels is essential in a hospital setting, where quiet is critical.

Modular Expansion Possibility:
Installing a nearby switch station to ensure faster capsule delivery. Currently, the system's network switch is located far from the destination, slowing sample delivery due to system load and distance. The pneumatic tube system could be designed to be modular, enabling future expansions such as connecting new departments or increasing capacity as demand grows.

The study is limited by its focus on a single healthcare institution, but a similar system is used in several healthcare institutions in Hungary. Extension to other databases and more reliable data from healthcare institutions in different regions could provide a comprehensive picture.
These proposals could contribute to a more efficient pneumatic tube system, thereby increasing accuracy, safety, and the satisfaction of healthcare institutions that use it. Additionally, the identified development opportunities could be useful in designing a pneumatic tube system tailored to meet Last-Mile Delivery needs in a designated area.
As presented in this chapter, numerous digital developments for the operation of the pneumatic tube system could be implemented to improve its efficiency, traceability, and transparency.

6 Conclusion

In recent years, the number of companies engaged in e-commerce has significantly increased, along with the volume of packages to be delivered. One possible solution to this growing demand in the future could be the implementation of a pneumatic tube system, for which numerous parameters need to be examined—these are discussed in detail. For this publication, I conducted questionnaire-based research at a healthcare institution in Hungary, focusing on the operation of pneumatic tube systems. This research highlights the potential issues and development opportunities that may arise during the implementation of such a system. Based on questionnaire analysis, development proposals, and interviews, I identified possible improvements to enhance or support the system's operation.
The study is limited by its focus on a single healthcare institution, but a similar system is used in several healthcare facilities across Hungary. Expanding the research to other databases and obtaining more reliable data from healthcare institutions in different regions could provide a more comprehensive overview. The presented study aimed to offer a new solution to meet increasing delivery demands by demonstrating the efficiency and potential uses of the pneumatic tube system.

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