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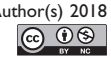

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# Identifying logistical parameters in hospitals: Does literature reflect integration in hospitals? A scoping study

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**Abstract**

In order to improve the quality and efficiency of hospitals, they can be viewed as a logistical system in which integration is a critical factor for performance. This paper describes the results of a scoping study that identifies the logistical parameters mentioned in international research on hospitals and indicates whether literature reflects system integration. When subsystems collaborate in order to accomplish the task of the entire organization, there is integration. A total number of 106 logistical parameters are identified in our study. In addition, the flow type – patients, materials and staff – and hospital subsystems were registered. The results presented in international literature show that logistics is highly fragmented in hospitals. Studies also show integration, although this takes place mainly within the subsystems of hospitals. A multi-agent perspective on hospitals is proposed, following the view that both integration and differentiation are essential for effective organizational performance. Given the widely recognised importance of controlling hospital costs and the potential of logistics to help in this process, it is important to gain more knowledge of hospitals as network organizations, as well as knowledge regarding the degree of integration and the logistical parameters that are required for better hospital performance.

**Keywords**

hospital, integration, logistics, scoping study, supply chain management

## Introduction

Healthcare costs are increasing in many countries.[1] Governments are looking for ways to control healthcare costs to guarantee, maintain or even improve the quality, accessibility and affordability of their healthcare systems.[2] There is increasing concern about the growth of healthcare spending.[3] Hospitals are a major cost item,[4] so there is a particular focus on hospitals when it comes to controlling the costs of healthcare.

In many industries outside the field of healthcare, it is argued that well-functioning logistics positively affects the operations of an organization.[5] Logistical optimisation has led to cost efficiency, quality improvement and customer satisfaction. It is argued that this can also be applied to hospitals.[6,7]

In the literature, it is argued that, although a well-functioning logistical system is critical for the overall functioning of healthcare operations, this support service is largely underestimated in hospitals.[8] Further, it is stated that 30 to 40% of hospital expenses are invested in various logistical activities,[5,6,9] and that almost half of the costs associated with supply chain processes could be eliminated through the use of best practices. These claims suggest that logistics is not given the attention it deserves.

Before the 1950s, logistics was thought of in military terms.[10] In those years, activities that are currently associated with logistics were organised in a fragmented way. There have been many changes since then; over time, a more integrated and broader perspective on logistics

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has been adopted.[5,11] With the introduction of supply chain management (SCM), the perspective changed from that of total cost integration to total system integration. SCM includes a chain orientation,[11] encompassing all activities from their origin to the point of consumption[5]; it aims to increase performance through the better use of internal and external capabilities[12] and is about everything that adds value for the customer and enhances competitive advantages.[13] In addition to SCM, there have been other theories and methods, such as lean six sigma, that promote integration.[14]

Healthcare logistics has been addressed in several studies, including overviews of literature on healthcare logistics[5,6,11,15] and operations management.[16] These studies consistently point out that academic research in this field is lacking[6,16] and that existing knowledge in the field is fragmented. It is suggested that healthcare is behind with respect to implementing SCM practices.[11]

The alignment of activities along the patient or material flow, often referring to the concept of integration, is central in the literature pertaining to logistics, SCM and lean perspectives in hospitals. Several papers state that the lack of integration within a hospital setting is attributable to the functional organization of medical disciplines and their facilitating departments, which do not share fixed resources.[16–18] In integrated hospitals, patient processes and resources are planned from the perspective of the total system,[19] in which the coordination of operations between the different members of the chain improves the entire patient flow.[20] Aronsson et al. state that in order for an organization to be effective, a supply chain strategy is required for the system as a whole.[6] In a more integrated perspective, attention is claimed for all hospital processes and resources,[21] instead of focusing on an individual department, such as the operating room (OR) or the intensive care unit. On a regional level, Poulin claims that horizontal interorganizational arrangements in relation to SCM are largely understudied.[9] It is not surprising that the literature argues that a systematic logistical approach to hospital strategy would lead to more efficient hospitals.[6,20] With regard to cooperation, Ludwig et al.[17] state that cooperation is a key issue in achieving high efficiency and quality in hospitals, not only on a departmental but also on a hospital-wide level. Evidence was found that efficient departments in a hospital did not necessarily make the entire hospital efficient.[10] Interdepartmental cooperation not only increases efficiency but also leads to better service for patients.[22,23] Accordingly, cooperation is considered essential for hospital efficiency on a departmental as well as on the hospital-wide level.

Despite the evident need for more integration, De Vries and Huijsman[11] remark that the question of how integration can be achieved is relatively unaddressed in healthcare settings. In addition, they state that the application of SCM is considered to be more complex in healthcare settings and may require a different approach than in other industries.

Lawrence and Lorsch state that both integration and differentiation are essential in order for an organization to perform effectively.[24] They define integration as 'achieving unity of effort among the various subsystems in the accomplishment of the organization's task'. Differentiation refers to 'the state of segmentation of the organizational system into subsystems'. Subsystems execute a part of the organization's task and 'develop particular attributes in relation to the requirements posed by their relevant external environment'. A subsystem therefore is not necessarily a fixed part of the organization, but its definition depends on the requirements of the external (sub)environment and how tasks are divided into subtasks.[24]

When subsystems perform subtasks individually, without the efforts of each subsystem being integrated to achieve unity of effort, there is fragmentation. Therefore, when studying hospital logistics, all the relevant parts of the system should be included, rather than examining the contribution of each department individually.[16] A strong emphasis on process orientation in research,[11] instead of focusing on functional silos, is in line with this perspective.

According to Lawrence and Lorsch,[24] subsystems can develop a primary concern with their own goals when dealing with their particular (sub)environment. This may lead to different parameters being used and pursued by different parts in one organization. Given the recommendations in the literature on logistical approaches and more integration in hospitals, it would be interesting to know which logistical parameters are used in hospitals. Therefore, in order to thoroughly understand the state of affairs in hospitals with respect to logistics and system integration, this research addresses two questions. Which logistical parameters are mentioned in the international literature with regard to hospital logistics? In what way does the literature reflect system integration in hospitals?

## Methods

As hospital logistics is a broad topic, a scoping study was conducted. As opposed to a systematic review, this type of literature research addresses broader topics in which many different study designs are applicable.[25]

Given the breadth of the concepts included, it was considered unlikely that we would be able to address very specific research questions or that we would be able to assess the quality of the studies included, as most systematic reviews aim to do. It is argued that scoping studies can be undertaken as methods in their

own right, especially in the case of complex topics that have not been extensively reviewed previously.[25] We believe that this is the case with our research. The main goal of the scoping study is to summarise and thus disseminate our findings to strategy and policy makers, as well as to hospital practitioners.

Identifying relevant studies was done through a number of searches in PubMed, Ebscohost and JSTOR. PubMed was selected because it includes a large number of international and clinical articles. Ebscohost is also internationally oriented and has a large number of articles but is focused on business economics. In addition, JSTOR was used for both areas, as business and life sciences are included in this database, as well as mathematics and statistics, which are often used in logistics.

Only articles written in English and from the period 2006–2016 were included. Even with these restrictions, initial searches using the keywords 'Logistics' and 'Hospital' led to over 400,000 articles. It was therefore decided to start with a search for these keywords in the Title and Abstract of articles only. The argument was that this would result in a set of articles for which the main topic would be logistics in hospitals.

The first search for 'Hospital' and 'Logistics' in PubMed, Ebscohost and JSTOR resulted in 414 articles. In order to identify other search terms, articles referenced in the 414 articles were analysed. Through an iterative process of searching, the following keyword searches were identified:

- Hospital AND Logistics
- Hospital AND Process AND Flow
- Hospital AND Supply Chain Management
- Hospital AND Operations Management

The articles found in these searches were all recorded in an Endnote database. All articles were screened for logistical parameters by reading the abstract. For each article, the parameters mentioned were noted. These could be parameters that were explicitly studied or parameters considered relevant to the research topic.

For each of the articles that mention logistical parameters, not only was the parameter captured in a database, but the logistical flow type in hospitals – patients, materials and staff – was also noted. The first argument for this was to see what parameters were used in the context of each flow type and to see whether there were similarities or differences in the parameters between these different flows and processes. The second argument was to see whether these flows, which come together at the end of the supply chain in, for example, the OR, have been studied in relation to one another. In cases where a combination of these flow types was included in the article, such data were registered as well. In addition to this, for each article, it was noted whether the logistical parameters were used in a hospital-wide context or in a specific part of the hospital. In case the abstract did not reveal the context, the full text of the article was read. The part of a hospital a study focuses on was also included in the database.

The logistical parameters found were then clustered into concepts. The concepts were identified by first splitting all logistical parameters into separate words – i.e. 'Transport Distance' resulted in two words: transport and distance. All words that represent a variable that could be quantified were labelled as a performance variable. Thus, in the example of 'Transport Distance', 'Distance' was labelled as a variable. All parameters that included the same variable were clustered into a concept. In the example of 'Transport Distance', all parameters including the term 'distance' were clustered in the concept of 'Distance'.

In order to establish the saturation level in a systematic way, the number of new parameters accumulated with each search was counted. One search is defined as one unique combination of keywords in one database (PubMed, Ebscohost, JSTOR), i.e. 'Hospital and Logistics' in PubMed. Saturation was reached when, in two searches, no new parameters were found. In addition to this, the number of new logistical parameters accumulated with each article in relation to the other articles was also calculated.

The parameter occurrence was measured as follows:

$P_n = p_x/n$ the number of times a unique parameter is mentioned ($p_1 \ldots p_{106}$) in relation to the total number of articles ($n$), presented as a percentage.

An independent reviewer assessed the search results by reproducing them. In addition, the reviewer took samples from the article database to see whether the logistical parameters identified matched those in the articles. The saturation level and the results were also verified by the reviewer. To ensure the saturation was still established when using Web of Science, we selected and screened the abstracts of papers using the defined keyword searches.

## Results

### Articles

The searches led to a total of 1093 articles in the three abovementioned databases (Figure 1). Of the 1093 articles, 47 duplicates were excluded. All the remaining 1046 articles were screened for logistical parameters by reading the abstract. No logistical parameters were found in 759 articles, so these articles were thus excluded from further analysis. In 287 articles, logistical parameters were mentioned (Figure 1). For these 287 articles, included in Supplementary Material Appendix 1,

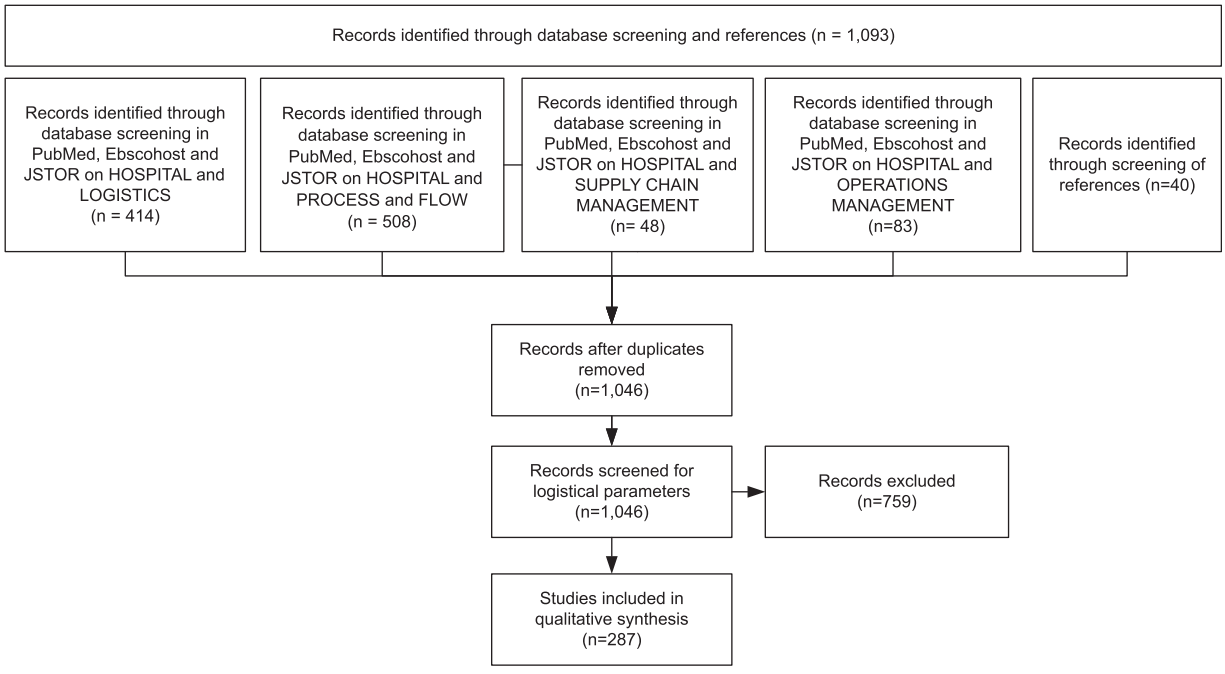



**Figure 1.** Search strategy presented according to PRISMA.[26]

the parameters mentioned were noted. These could be parameters that were explicitly studied or parameters considered relevant to the research topic.

## *Logistical parameters*

In the 287 articles, 106 different logistical parameters were found. The saturation level was reached when at some point no new parameters were found in the consecutive screening of abstracts. Another indication that no other logistical parameters were to be found and saturation had been reached was the fact that in 82 articles a new parameter was found and in 209 articles no new parameters were found. Based on this, it was considered unlikely that more new logistical parameters would be found and saturation was established. This was confirmed by an independent reviewer. In Supplementary Material Appendix 2, all 106 parameters are presented in alphabetical order, including the relative number of times that a parameter was, as a percentage, mentioned in the set of 287 articles.

In total, 24 parameters comprise 80% of the total number of times a parameter was found in an article. The remaining 20% is made up of 81 different parameters. It is also observed that 79 parameters are mentioned in less than 1% of all articles. This suggests a relatively large variety of logistical parameters, which, perhaps, are not frequently used under the same name.

To provide an overview on the parameters mentioned most, Figure 2 shows the 27 parameters that are mentioned in more than 1% of the articles. Length of stay is the most mentioned parameter, cited in 30% of the 287 articles, followed by waiting time and wait time (28% in total), resource utilisation (18%) and lead time (16%). Cost and delay are also mentioned frequently, in 15% and 10%, respectively, of the articles.

Looking at all the parameters, it is noticeable that the same or similar words are used in the names of different parameters. In all 106 logistical parameters, 11 words referring to a performance variable were used in the name of more than one parameter: Time, Cost, Availability, Utilisation, Distance, Spent, Throughput, Efficiency, Length, Occupancy and Reliability. These terms refer to concepts, in which the parameters could be clustered. In the definition of the concepts, 'Spent' and 'Occupancy' were eliminated as separate concepts. 'Spent' was eliminated as a cluster, since it refers to either time or money (cost) spent. 'Length' was also not considered as cluster because it refers to time or distance. 'Occupancy' was seen as similar to 'Utilisation'. This resulted in eight clusters. In total 81 logistical parameters fit into one of these concepts. Another nine parameters referred to four additional concepts that were then added: Waste, Responsiveness, Rework and Waiting patients. The remaining 16 parameters were not clustered into a concept but labelled as 'Miscellaneous'.

In total, 90 parameters could be clustered into 12 concepts. The results of the clustering are presented in Supplementary Material Appendix 3.

Time is clearly the concept mentioned most: 39 logistical parameters refer to time and 14 of the most

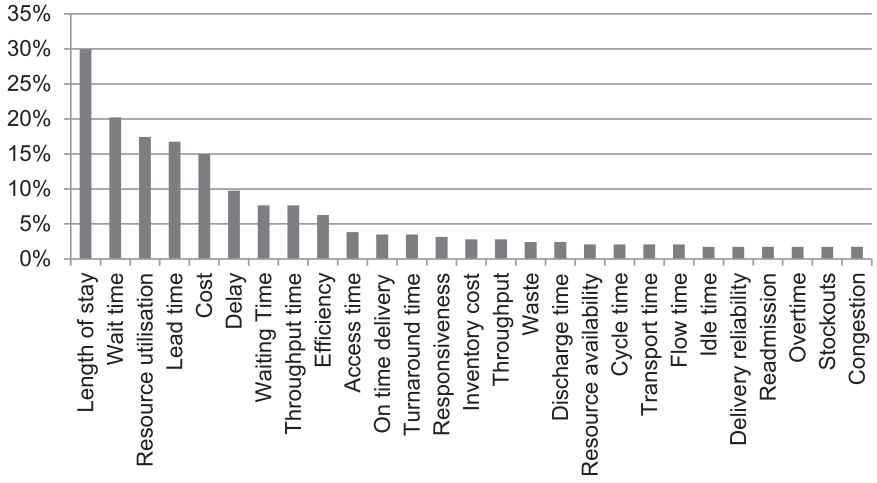



**Figure 2.** Parameter occurrence ($P_n$) of 27 parameters in relation to the total number of articles (%).

mentioned parameters (Figure 2) are related to time. Note that 'Length of stay' and 'Delay' are included in the concept of Time. In this case, it is clear that 'length' does not refer to distance but to time duration. 'Delay' is also clearly expressed as time duration.

Cost also seems to be important, as parameters related to cost are mentioned in 11% of all the parameters noted. Utilisation and Availability both refer to resources; the resources mentioned in the logistical parameters are beds, materials (e.g. inventory, stock), space, infrastructure (e.g. floors, elevators and warehouse) and staff.

Given the argument that logistics includes an integral way of thinking, it is remarkable that 47% of the articles refer to one parameter. Two parameters are mentioned in 26% of the articles and more than three different parameters are mentioned in 27% of the articles.

## *Logistical parameters according to flow types*

Most articles found are on patients, as shown in Figure 3. In 83% of the articles, patient flows are the only logistical flow mentioned. Almost 12% of the articles are on materials. The minority of articles is on staff (2%) or had no specific focus (2%). In 1% of the articles, both materials and patients were mentioned.

By observing what logistical parameters are mentioned for each flow type, it can be observed that each flow type has both different and similar parameters. First of all, it is remarkable that the terminology used in a patient flow context is different from the terminology used in a material or staff flow context. If we look at the 10 most mentioned parameters per flow type, 'Efficiency' and 'Lead time' are the only two parameters which are mentioned in all three contexts of patients, materials and staff. In addition to this being a difference

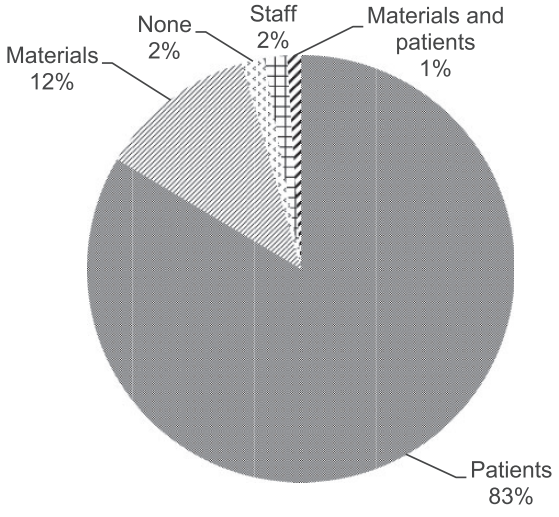


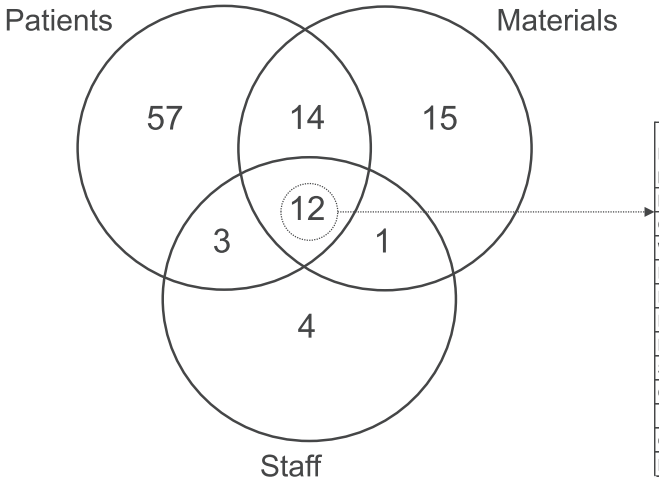

**Figure 3.** Flow types in the articles.

in terminology, it suggests different priorities per flow type.

Figure 4 shows how many logistical parameters are mentioned in the context of each flow. A total of 76 parameters are mentioned in the context of one flow type: 57 parameters in the context of patient flow, 15 in materials and 4 in staff flows. Twelve parameters are mentioned in all flow type contexts, i.e. in patient, material and staff flows.

## *Hospital-wide or subsystem*

Looking at the context of the studies in the 287 articles, 15% of all articles mention logistical parameters in a hospital-wide context.[20,27,28] The other 85% of the articles mention logistical parameters in a specific context or subsystem of a hospital. We regard a subsystem




| Logistical parameter | Parameter occurrence ($P_n$) |
|---|---|
| Lead time | 16% |
| Cost | 15% |
| Waiting Time | 8% |
| Efficiency | 6% |
| Responsiveness | 3% |
| Resource availability | 2% |
| Delivery reliability | 2% |
| Stockouts | 2% |
| Capacity utilization | 0.3% |
| Inventory waste | 0.3% |
| Occupancy rate | 0.3% |
| Processing waste | 0.3% |

**Figure 4.** Number of logistical parameters per flow type or combination of flow types.

as a part of the organization that performs a portion of the organization's task. We found three types of subsystems: a department, flow type and process type.

There are several studies on the emergency department (18%), the operating theatre department (6%), the intensive care department (3%) and nursing departments (3%).

Studies on specific flow types focus, for example, on blood logistics (2%) or orthopaedic patients (1%). There are also studies on specific processes, such as the discharge process (2%) or the internal transport process (2%).

In total, we identified 92 subsystems in 287 articles, as presented in Supplementary Material Appendix 4. For 64 subsystems (22%), there was only one article in that specific context mentioning logistical parameters. As an example, we mention 10 subsystems for which our database includes one article: ancillary services departments, the process of giving injections, paediatric cardiac patients, hip fracture patients, the pre-operative department, HIV/aids patients, ambulatory surgery patients, the inpatient rehabilitation department, patient transfer, laparoscopic patients, the sterilisation department and medical equipment.

## Discussion

The results of this scoping study indicate that there is fragmentation of logistics in hospitals, as reported in the international literature. The 106 parameters could be clustered into 12 concepts, but the fact that these parameters are used in 92 subsystems leaves us with questions as to whether logistical parameters have the same meaning or serve the same purpose in these different subsystems. A clear integrated view of hospital performance control or improvement could not be derived from the international literature on logistical parameters.

It is also observed that many logistical parameters were either defined in an ambiguous way or were not defined at all in the literature. Wait time and waiting time are clearly two words with the same meaning, but lead time and throughput time are, perhaps, not. Moreover, in a patient flow context, lead time could be measured in a different way than when examined in a material flow context. In many articles, this was neither explained nor specified.

Fragmentation is also demonstrated as almost 50% of the articles mention only one parameter, indicating that many studies fail to analyse performance along more than one dimension. In addition, different parameters seem to be important to different logistical flows. Frameworks that have been developed in the past provide structure, but employ a limited perspective on material flows[29] or on patient flows.[30]

At the same time, there is a certain integration included in the studies analysed in this scoping study. Several studies apply an integrative approach to a part of the hospital. This could be a department, flow type or process. However, integration of patient and material flows within one department or process does not necessarily mean that an entire hospital's performance will increase. If a study shows, for example, that the integration of the healthcare process for acute patients improves the hospital's performance for these patients, it is not clear whether this benefits the entire hospital. The articles found show separate parameters without cohesion. There does not seem to be a clear concept on how logistics for the hospital should function as a whole and how integration and differentiation of tasks contribute to the hospital's performance overall.

From this scoping study, we therefore conclude that logistical parameters are numerous, ambiguous and used in very different contexts in the international literature. When combined, these do not reflect an integrated

approach with regard to (the study of) hospital logistics. This leads to the question of the possible reasons for this, especially when considering that integration is regarded as essential.

We could argue that research has not yet given much attention to logistics from the perspective of integration. However, given the many articles that claim the necessity for integration in hospitals, logistics does not appear to be irrelevant to hospitals. In a patient context, there is certainly attention shown in the international literature for improving both length of stay and waiting times, as illustrated by the 143 articles that mention these parameters. Also, numerous studies have been conducted on logistics in emergency departments. Moreover, frameworks have been developed for assessing logistical performance, clearly indicating a need for controlling and improving hospital logistics. Repeatedly, the relevance of an integrated perspective on hospitals is presented in the literature.[6,11,17,19,20,22]

Several studies note that logistics in a hospital could be too hard to oversee. Researchers state that understanding and improving hospitals is complex,[6] hard,[31] extremely challenging[30,32] and problematic.[11] This scoping study supports evidence for this argument. Studying 106 different parameters in three different flow types and in 92 subsystems appears to be something of a 'mission impossible' for researchers. This might explain why there is no complete, empirical-based theory of hospital logistics.

The challenges faced by researchers on hospital logistics might also have serious implications for the management of a hospital, particularly for strategic management. Given the large investments made in hospitals, and the need to control healthcare costs, we consider an integrative perspective on hospitals and the inclusion of logistical parameters in strategic decision making to be important. However, we agree with De Vries and Huijsman[11] that there is a current need to better understand *how* to do so. We would like to add the question of *what* integration is in a hospital.

We believe integration includes coordination and cooperation between entities that function together as a unified whole. Hospitals should be seen as a network of more or less dependent agents. Agents are capable of autonomous actions and base their actions on the environment in which they are situated in order to meet their own objectives.[33] To what extent integration is required depends on what services are demanded from agents by their environment and to what extent they need to align and coordinate their activities with those of other agents in order to deliver the required service.

It is also important to state that integration should serve a purpose. The purpose depends largely on what demands agents in the hospital's environment put to the hospital or its agents. Agents in the environment could be patients, general practitioners or entire communities. In theory, there could be too much integration, especially when it does not add further value. Following the same reasoning, fragmentation could be effective if an agent is capable of providing good service without having to coordinate with other agents. In that case, we should rather speak of differentiation.[24]

It would be interesting to gain more knowledge of the cases in which integration and differentiation are essential for hospital performance and what circumstances play a role in this. We need to know what agents are part of a hospital, to what degree they should or should not act independently and to what extent integration or alignment between agents is required for improvement of a hospital's overall performance. Further research should lead to new frameworks, consisting of multiple parameters relating to the interests of individual agents, as well as, on hospital-wide level, relating to the various demands stemming from the hospital's environment.

This scoping study certainly has its limitations: the international literature does not, by definition, reflect what really happens in hospitals. It could be the case that multiple agents in the hospital interact, negotiate or coordinate activities, but that this is not known publicly, perhaps for reasons of confidentiality. Another reason could be that there is literature on integrative approaches, but that it is not described in logistical terms. This could be explained by the fact that most people working in hospitals – i.e. doctors, nurses – do not use logistical terms. Further empirical research on how logistical networks of agents in hospitals work, what parameters they use and whether and when integration or differentiation are detrimental or in fact beneficial to a hospital's performance is therefore recommended.

This study provides an overview of all possible logistical parameters in hospitals; these are used in several contexts and need further structuring in order to be useful in practice. It should therefore be seen as a starting point for further research in which these findings are explored from a multi-agent perspective. In future research, hospital agents could be identified, as well as the various networks of agents interacting in subsystems. The study of what logistical parameters they use for optimising their interests and how these should be used and managed in an integrated way could make an important contribution to the improvement of hospital performance.

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## Supplemental Material

Supplemental material for this article is available online.

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