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Review

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ABSTRACT

Hospital material management has been identified as one key cost containment lever to cope with steadily increasing healthcare costs in industrialized countries. The purpose of this work is to present the state-of-the-art of research on material logistics management in hospitals. Particular focus is given to articles that apply quantitative methods. Our contribution is threefold: First, we provide research guidance through categorizing literature and identifying major research streams. Second, we discuss applied methodologies and third, we identify future research directions. A systematic approach is undertaken in order to identify the relevant literature from 1998 to 2014. Applicable publications are categorized thematically and methodologically and future research opportunities are worked out. In total, 145 publications are identified and discussed in this work. The literature is categorized into four streams, i.e., (1) Supply and procurement, (2) Inventory management, (3) Distribution and scheduling, and (4) Holistic supply chain management. The use of optimization techniques is constantly gaining importance. The number of respective publications has continually grown and has peaked over the last three years. Optimization has been successfully applied in research streams (1), (2), and (3). Category (4) comprises a rather qualitative research field of literature dealing with supply chain management issues.

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1. Introduction

In the countries of the OECD, total healthcare expenditures have grown with an average of 4% per year from 2000 to 2009 [127]. Hospitals account for 29% of total healthcare expenditures [128]. Of hospital costs, more than 30% are linked to logistics activities [122]. This makes logistics costs the second largest cost block after personnel costs [138,148]. Compared to other industries, material management and logistics have not been given high priority in hospital management research in the past. Possible reasons are the high complexity of healthcare supply chains and their merely supporting role in the foremost goal of hospital management, i.e., effective treatment of patients [13]. However, in the last fifteen to twenty years, logistics has been identified as one key lever to manage healthcare costs [164,33]. Research estimates that through efficient logistics management, around half of the logistics-related costs in hospitals can be eliminated [138].

The potential of hospital logistics optimization within the healthcare sector is considered significant both by academia and practitioners. The most obvious upside from optimizing material logistics is that cost reductions do not directly affect the quality of patient care [78]. In contrast, logistics-related activities are often performed by medical staff, taking away time from taking care of patients. In a recent survey among registered nurses in the U.S., time wasted on activities other than patient care, such as restocking supplies, was the major driver that negatively impacted nurses' time at bedside [75]. Relieving nurses from non-patient care related activities can thus improve the quality of care.

The aim of this work is to present the state-of-the-art of research on material logistics management in hospitals. In the discussion, we set a distinct focus on publications that apply quantitative methods. Respective papers are discussed in detail, e.g., by providing tables with deep-dive analyses on the applied methodologies. Our contribution is threefold: First, we provide research guidance by categorizing the literature and identifying major research streams. Second, we discuss applied methodologies and third, we identify future research directions. There exist rather general literature reviews on healthcare operations research/operations management (e.g., [42,68,141]). Also, a number of reviews exist on supply chain management (SCM) in healthcare, e.g., de Vries and Huijsman [165], who focus on the question whether or not there exist parallels between the industrial sector and healthcare services. Dobrzykowski et al. [38] thematically assess a more general scope than this work as they include operations management topics like service management, planning, and scheduling. Furthermore, they limit their review to publications from seven U.S. journals only and

review a different time period (1982 to 2011). Consequently, to the best of our knowledge, there is currently no comprehensive review on material logistics in hospitals with a focus on quantitative methods. This publication fills the research gap.

The remainder of this article is structured as follows. Section 2 presents the methodology of the literature review and introduces a framework to cluster the relevant literature thematically. Section 3 provides a quantitative overview of topics, applied methodologies, and the regional coverage of assessed publications. Furthermore, an overview of all publications is provided. Sections 4–7 discuss the literature along this framework and point out future research potential. We present a conclusion and a summary of research opportunities in the final section.

2. Methodology

2.1. Scope

This paper reviews all relevant publications regarding the logistics activities of handling physical goods in hospitals. Physical goods comprise all items that are directly linked to the care of patients, like pharmaceuticals, medical consumables, food, laundry, sterile items, laboratory samples, waste, etc. Pharmaceuticals represent 70% to 80% of the supply costs, while medical-surgical materials account for 20% to 25% [142]. Non-patient care related products, e.g., office supplies, mail, etc., are excluded. Further, although partly included in logistics activities, flow of information is excluded. Due to its distinct characteristics, such as the irregularity of supply and the lacking comparability to the items stated above, blood products are out of scope of this review. Comprehensive reviews on SCM of blood products are available in the literature [149,15]. Considering the supply chain of goods from manufacturing to use, this review starts with the supply chain partners one step upstream from the hospital, i.e., typically the hospital-supplier interface. One exception is Section 4.4, where we shed light on the interface between drug manufacturers and wholesalers and implications for hospital purchasing. Also, reverse logistics is not in particular scope of this publication, however we refer to Srivastava [152] for designing a reverse logistics network. Logistics activities associated with outpatient treatment, like home delivery of meals or outpatient medication, are out of scope. Exemplarily, Liu et al. [104] present related work. Our restriction of scope is in line with existent literature, as hospital-internal logistics activities are the major source of competitiveness within healthcare material management [144,97]. Personnel planning and scheduling that is not

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