



## Decision Support

# Medical device maintenance outsourcing: Have operation management research and management theories forgotten the medical engineering community? A mapping review

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## ABSTRACT

In this paper, we examine the large body of existing research on outsourcing, and assess the status of research on outsourcing the maintenance of medical devices. Because so little research in this area currently exists, the study was broadened to include other fields that outsource maintenance services, and considers possible applications to the field of medical device maintenance. In all, this paper examines 55 articles spanning various dimensions, including: mathematical models, empirical studies, and conceptual papers. We conclude that research into the outsourcing of medical device maintenance services in hospitals is still in its infancy stages, and that further progress in this field would benefit from additional empirical study grounded in management theory.

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## 1. Introduction

Medical technology management is a systematic process that begins with strategic planning, technology assessment, and facilities planning. Once the institution has determined its technological needs, the process proceeds with technology procurement, and concludes with maintenance management (Judd, 2004: p. 159). When a health care institution lacks the technical skills or specialized assets needed for the maintenance of its medical technology, maintenance should be outsourced.

Yet while outsourcing has grown in popularity, research on maintenance outsourcing in academic literature remains scarce. Our review of the literature confirms the findings of Jackson and Pascual (2008) that there is no study on maintenance service outsourcing that deals with the problems of service provider selection, evaluation, and performance measurement in an integrated manner. In the healthcare environment these problems are worthy of study, as healthcare institutions lacking the capacity to deal with these issues may face significantly higher costs. For example, it has been reported that some maintenance service providers—in most cases the original equipment manufacturer (OEM)—have created barriers to service competition by denying training or documentation to potential competitors, and withholding replacement parts (Blumberg, 2004: p. 138). For healthcare institutions in developing countries, where contracting maintenance services is often inevitable because

hospitals have fewer properly trained employees on staff and less material resources are available to handle in-house maintenance, opportunistic behavior and anticompetitive practices can be even worse. These findings suggest a gap between client needs and contractor performance, prompting many studies to tackle the problem of critical elements related to maintenance outsourcing processes in general, although little research exists examining the particular case of medical device maintenance outsourcing.

Thus, this paper is the first stage of research to answer the three questions formulated below. The overall goal of this study is to identify representative research measuring the performance of outsourced medical device maintenance in the hospital environment, using management theories and/or strategic management theories,<sup>2</sup> or mathematical models. Since little research currently exists in the field of medical device maintenance outsourcing, we also identify literature on maintenance outsourcing in general that could be applied to the medical devices field. The specific research questions of this review are therefore:

1. Which are the most common dependent and independent variables for evaluating maintenance performance and outsourcing decision problems, both in the hospital environment and other technical fields?

<sup>2</sup> In this paper we will use the term 'theory' to refer to a set of logically interrelated propositions or 'arguments' that make assertions about the nature of relationships between theoretical constructs (Walker and Cohen, 1985). Likewise, a 'management theory' is understood as the conceptual framework for organizing knowledge and providing a blueprint for action to assist or guide organizations toward their objectives (Raduan et al., 2009).

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2. What are the existing research gaps, and what future studies can be done in the field to evaluate the performance of medical device maintenance services?
3. How does a paper's methodology, outsourcing problems tackled, area subject,<sup>3</sup> percentage of self citations, management theories used to ground its hypothesis, the percentage of review papers appearing in the journal, and the industry research was conducted in affect the article's impact, as measured by the Source Normalized Impact per Paper (SNIP)<sup>4</sup> the article receives?

## 2. Motivation

The assessment of maintenance service provider performance is an intriguing and timely research topic that deserves more comprehensive study. Within this topic, two particular problems stand out. First, the two key elements in managing a maintenance service supplier are supplier selection and performance assessment. However, performance assessment has received less scholarly attention (Kannan and Choon, 2003). For example, there is still little knowledge about the relationship between selection and performance (Billesbach et al., 1991). Second, because performance measurement is particularly difficult in the healthcare industry, given the interdependence of hospital services (Coles and Hesterly, 1998b), new methods for defining, standardizing, and evaluating performance variables are needed. These problems are particularly important in the healthcare field, as poor maintenance performance directly impacts medical equipment availability,<sup>5</sup> in turn lowering healthcare quality by increasing patient waiting times due to equipment downtime. Maintenance service provider performance must therefore be strictly monitored.

Examining these issues from the perspective of management and strategic management theory may provide useful insight. Several management theories have posited theses on how contract governance structure might impact firm performance, though less of this research has been directed at maintenance outsourcing in particular. For example, Transaction Cost Economics (TCE)<sup>6</sup> focuses on different levels of analysis, including; (1) determining which activities should be performed within the firm, and which should be outsourced (also known as defining the boundaries of the firm), and (2) firm efficiency. TCE predicts that by drawing efficient boundaries (Bigelow, 2006, Klaas et al., 2001, Poppo and Zenger, 1998), a firm enhances its performance. On the other hand, an influential strategic management theory, the Resource Based View (RBV), predicts that certain types of resources owned and controlled by firms have the potential to generate competitive advantages and higher performance levels. Thus, one of the major concerns of RBV is how an organization's capabilities develop and affect performance. Under the fundamentals of RBV, outsourcing decisions are influenced by the ability of an organization to invest in developing a sustainable performance advantage over competitors. Thus, studying maintenance service performance from the perspective of management and strategic management theories might be useful in two key ways:

<sup>3</sup> Scopus classified its journals into 27 major subject areas, which in turn are sub-classified into 313 specific subject categories (e.g. Subject area: Business management and accounting; Specific subject categories: accounting, marketing, industrial relations, organizational behavior, etc.)

<sup>4</sup> SNIP is a measure of paper impact proposed by Moed (2010) and is covered by the Scopus database.

<sup>5</sup> Availability: is the probability that a piece of equipment is operational when service is needed, calculated as the ratio of Hours operational/(Hours operational+Hours no operational).

<sup>6</sup> As TCE is a normative theory that posit what firms should do and not a strategic management theory, we make the distinction in the third group of papers. Still, there is no disagreement between TCE and strategic management theory regarding the effect of uncertainty alone; however when uncertainty and non-trivial levels of assets specificity are present there is some divergence between the two theories (Mick, 1990).

- (1) empirical findings may help maintenance service firms elaborate evidence-based strategies to obtain better performance levels than competitors, and (2) health care institutions will have the opportunity to make better-informed maintenance outsourcing decisions.

This paper is organized as follows: We begin by presenting the data and methods. We then proceed with the results section, where the main questions formulated in this paper are answered. In the discussion section, we present the main research gaps found and suggestions for future research.

## 3. Data and methods

### 3.1. Data sources

We consulted a range of academic archives to identify relevant research measuring the performance of medical device maintenance outsourcing and other outsourced services. The archives consulted included PubMed,<sup>7</sup> Proquest-AB I/Inform Global, ScienceDirect, JSTOR, and EconLit. The range of archives we selected was suitable because of its multidisciplinary nature, including extensive coverage of economics and other disciplines likely to publish work in the application of management theories, such as law, management, marketing, organizational behavior, operational research, and public administration (David and Shin-Ka, 2004). Additionally, we used the Scopus database to cross-check the references found in PubMed and Proquest-AB I/Inform Global, JSTOR, ScienceDirect, JSTOR, and EconLit to detect any paper omitted. By including a variety of databases, we were able to guarantee a more thorough search and achieve greater levels of sensitivity (Scherer et al., 1994).

### 3.2. Methods

For this mapping review<sup>8</sup> we followed a review protocol with four major steps: we first determined the search strategy, then performed the literature search, conducted a selection process for relevant articles, and finally extracted data for analysis. We first conducted a search of the PubMed database, preceded by searches of the Proquest-AB I/Inform Global, ScienceDirect, JSTOR, and EconLit databases, according to the combinations of keywords with Boolean operators (see Table A.1 Appendix A). The database searches found a total of 213 papers related to maintenance outsourcing. We followed the process described by Carroll et al. (2004) for paper selection. Any paper that came up in multiple databases was counted as one entry. We excluded papers that presented results or measured the performance of long-term commercial contracts, informal agreements, and franchise contracting governance forms, because these contract forms are rarely used in medical device maintenance. This process resulted in the exclusion of 158 papers that did not meet the inclusion criteria (see Fig. 1 and Table A.1 Appendix A), leaving a final sample of 55 papers to be analysed (see Fig. 1b, and Tables A.2 and A.3 Appendix A).

Of the 213 papers found, the distribution of papers according to language of publication was as follows: English (95.32%), German (2.34%), Japanese (1.175%), Chinese (0.58%), and Finnish (0.58%). The exclusion of non-English papers from this initial sample represented only 4.68% of the total. Therefore, the so-called Tower-of-Babel bias described by Dickersin et al. (1992) for excluding non-English language papers was minimal. The inclusion of papers with positive and negative results eliminated the possibility of the

<sup>7</sup> PubMed is a web site from the United States National Library of Medicine.

<sup>8</sup> A mapping review is a literature review that follows Search, Synthesis and Analysis (SALSA) framework to map and categorize current literature, in order to orient further research by identifying gaps in research literature. Thus, this sort of review may characterize studies in ways such as theoretical, perspective, or specific setting (Grant and Booth, 2009).

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