

Chapter 2

A Comprehensive Survey on Healthcare Management

Sezi Cevik Onar, Basar Oztaysi, and Cengiz Kahraman

2.1 Introduction

Healthcare management is the scientific field which provides leadership and direction to healthcare organizations. The public health systems, healthcare systems, hospitals, and hospital networks are the main research areas in healthcare management. In these healthcare organizations, there usually exist numerous types of healthcare problems which might be micro such as scheduling of an operating rooms or macro such as layout of the whole healthcare organization. These problems can be solved by quantitative and qualitative techniques such as operations research techniques, simulation or decision making techniques.

Management of healthcare organizations needs complex and dynamic operations. Managers in these organizations should perform a successful leadership, supervision, and coordination of the employees. They should be aware of the quantitative and qualitative techniques that can be used in the solutions of various problems of healthcare organizations. In the literature, there are many healthcare applications of these techniques. However, there is a need for a work classifying these studies based on the types of techniques and the healthcare problems solved by these techniques.

Figure 2.1 illustrates the increasing trend of healthcare management publications over the years. The statistics in Fig. 2.1 are from Scopus database with the keyword *healthcare management* in the title of the publications. This search gave us 2,250 papers. There is a significant increase in the number of publications after 1998. This proves that a significant importance is given to healthcare management research in the literature for the last two decades.

S. Cevik Onar (✉) • B. Oztaysi • C. Kahraman

Department of Industrial Engineering, Istanbul Technical University, Macka, Istanbul, Turkey
e-mail: sezi@outlook.com

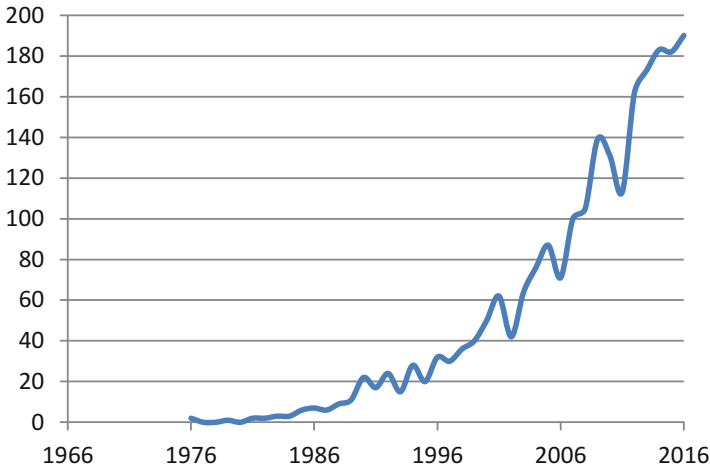


Fig. 2.1 Healthcare Management publications with respect to years

The aim of this chapter is to exhibit the existing position of healthcare management in the literature. We classified the healthcare problems and their solution techniques in the literature in order to see the general frame of healthcare management. OR techniques are also included within this classification. This aims at showing the place of OR in the whole picture. A comprehensive and up to date literature survey is conducted by using a broader perspective that considers both qualitative and quantitative techniques.

The rest of the chapter is organized as follows. Section 2.2 presents the literature review results based on the classifications with respect to papers conducting a review of qualitative and quantitative techniques on HCM. Section 2.3 classifies the techniques used in healthcare management. Finally, Sect. 2.4 concludes the chapter and presents future directions.

2.2 Sub-classifications of HCM Studies

There is a significant increase in the HCM studies in the recent years. United States and United Kingdom are the first two by far leading countries in publishing healthcare works. In this manner, the second class of countries includes Finland, Canada, India, Italy, France, and Germany; the third class includes Brazil, Australia, Israel, Netherlands, and Taiwan. Figure 2.2 illustrates the countries most publishing healthcare works. It is interesting that China, one of the leading countries in many research areas, is about 20th place in this list. A publication is counted more than one if its authors are from different countries.

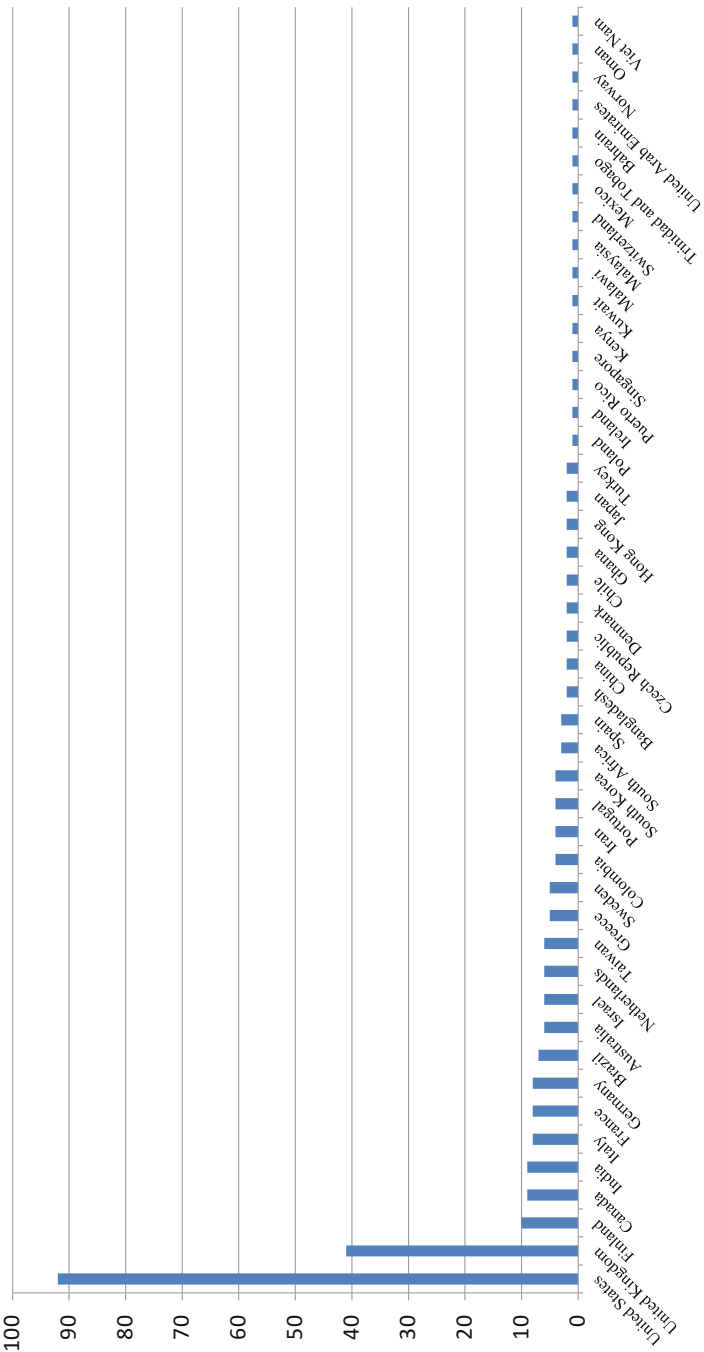


Fig. 2.2 Countries publishing in Healthcare Management

Some institutes focus on healthcare research more than the others. Texas A&M University, University of Southampton, Ben-Grurion University of the Negev, Cardiff University, and VA Medical Center are the leading institutes publishing healthcare papers.

In the following, HCM papers are classified as literature review papers, qualitative and quantitative techniques, case studies, and performance measurement paper, and some representative papers are given.

2.2.1 HCM Papers Making Literature Review

Some researchers have attempted to review the literature on qualitative and quantitative techniques utilized in healthcare management systems. Fakhimi and Mustafee (2012) focus on synthesizing extant literature in healthcare OR by classifying papers based on OR techniques, application category, healthcare specialty, among others. The scope of this review article is limited to OR studies undertaken in the UK. Ozcan (2009) presents the quantitative methods used in healthcare management with their applications, including decision trees, forecasting techniques, facility layout and facility location techniques, and scheduling techniques. Tanfani and Testi (2012) edit a book on advanced decision making methods applied to healthcare, including the applications of operational research, statistical and economic decision-making tools in the field of healthcare delivery. Cox (2006) presents the traditional quantitative risk assessment techniques for the human health consequences of using antibiotics in food animals. These techniques include Bayesian Monte Carlo analysis, rapid risk rating technique, etc.

Some other researchers made literature reviews on various healthcare problem areas. Lavis et al. (2005) review studies of decision-making by health care managers and policy-makers. They claim that literature reviews are necessary for developing better inform health care management systems and effective policy-making. Kontio et al. (2007) present a literature review on the benefits of healthcare information systems and enterprise resource planning (ERP) systems in healthcare. The study is conducted using a meta-summary technique for qualitative research. Kamarudeen (2010) reviews the literature to reveal the impact of healthcare system on the amenable mortality rates in the OECD countries. Rais and Vianaa (2011) review key contributions addressing contemporary optimization issues in the domain of healthcare. The study focusses on the optimization problems in current research activities and the solution techniques used for solving the optimization problems. Wang et al. (2011) present a literature review and analyze papers which use industrial and systems engineering and operations management methods to improve psychological healthcare. Matopoulos and Michailidou (2013) investigate the collaborative practices in the healthcare supply chain and give insights into hospital-vendor operations. Ashrafi et al. (2013) conduct a systematic review in order to reveal decision support applications and their effects on healthcare. The results indicate that decision support systems are applied to the five main areas, namely,

disease progress management, care and treatment, drug prescribing, evaluation and prevention. Fakhimi and Probert (2013) review the operations research techniques that are used in healthcare, and categorize these studies based on the application type and operation research technique employed. The results indicate that the majority of studies focus on simulation. Dobrzykowski et al. (2014) conduct a structured literature review on operation management and supply chain management (SCM) studies for healthcare. Al-Balushi et al. (2014) conduct a literature review in order to define the readiness factors that are critical to the application and success of lean operating principles in healthcare organizations. The above literature reviews focus on best practices and specific techniques and areas such as ERP usage and SCM practices in healthcare management. Their focus is not directly the quantitative and qualitative techniques used in healthcare management.

2.2.2 Quantitative and Qualitative Techniques in HCM

Since the 1960s, quantitative techniques and mathematical models, such as operations research models, have been applied to a range of healthcare problems. However, OR techniques have not been frequently used in the solution of healthcare problems by clinicians, health managers and policy-makers. Brailsford (2005) focuses on simulation models in healthcare management and briefly describes one successful implementation and suggests some potential ways forward. Green (2012) describes the essential features and critical issues of the United States (US) healthcare system that provide opportunities for operations researchers to make significant contributions. Garg et al. (2012) develop an intelligent patient management and resource planning model for complex, heterogeneous, and stochastic healthcare systems. Motamarri et al. (2014) analyze patients' perceptions on mobile healthcare services by multiple discriminant analysis. Sadatsafavi et al. (2015) investigate employees' perceptions of healthcare facilities and differences across demographic groups by using principal component analysis, confirmatory factor analysis, and invariance analysis. Xie and Lawley (2015) indicate that innovative OR techniques are developed for operating room planning, emergency department staffing, breast cancer screening, radiotherapy treatment planning, home healthcare planning, long-term care planning and scheduling.

In the following, we present some statistics based on the operations research applications in healthcare management. The data are obtained from Scopus database with the inputs healthcare and operations research. The distribution of the healthcare publications in OR is composed of articles with a percentage of 55; conference papers with a percentage of 31; review papers with a percentage of 7; book chapters with a percentage of 4; and books, notes, and editorials with a percentage less than 3. The main research areas of the operations research based healthcare publications are medicine, engineering, computer science, business and management, decision sciences, social sciences, health professions, mathematics, and nursing, respectively.

Qualitative methods for the solutions of healthcare management problems have been employed in some works. Robert et al. (1999) use Delphi study for identifying new healthcare technologies. Zonca et al. (2015) specify the competition in healthcare with a focus on surgery in the Czech Republic and use Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis.

2.2.3 Case Studies in HCM

Case studies in healthcare management have been also handled in numerous papers. Lavy and Shohet (2009) develop an integrated facilities management (FM) model for healthcare facilities and investigate the effectiveness of the model in terms of maintenance and performance management in a real world case study. Krey et al. (2010) provide an overview of the interrelated information technology (IT) governance frameworks and best practice models, analyze the potential impacts of IT governance on the Swiss healthcare and give an outlook of the related future research. Foster et al. (2010) illustrate the use and value of the tools of operations research in healthcare and focus on queuing theory. Applying queuing theory in a hypothetical drug treatment facility, some of the key performance measures, such as average waiting time for admission, are modeled using mathematical expressions. McAlearney et al. (2010) focus on potential links between high-performance work practices and quality of care and patient safety in US healthcare organizations. After an extended literature review the authors generate a model and confirm the model by five case studies. Nemeth and Cook (2010) focus on Resilience engineering in healthcare enterprises. Based on a 5-year case study, the authors present a concept for an infusion device interface that would contribute to resilience. Ahsan et al. (2010) design and provide the insight of an Enterprise architecture approach to process architecture for healthcare-IT alignment. They analyze healthcare organizational processes using a specific case study and conceptualize this analysis in order to provide an overview of healthcare processes in the context of enterprise architecture to improve healthcare management. Van Vactor (2011) presents a collaborative communications model which provides information to healthcare supply chain managers and administrators. Using the data obtained from a case study including healthcare supply chain managers in the US Army, the effects of collaborative communications on healthcare supply chain management is pointed out. Bora et al. (2011) describe a methodology to support the evaluation of the benefits provided by Radio Frequency Identification (RFID) on product traceability applications in healthcare sector and provide a real world case study. Bullock et al. (2013) analyze a United Kingdom (UK) knowledge exchange program designed to bring together healthcare managers and researchers with a case study.

2.2.4 Performance Measurement in HCM

There are several quantitative and qualitative techniques aiming at measuring the performance level of a healthcare organization or comparing its relative position with the other organizations. A healthcare organization should measure its performance since measuring performance provides quality improvement, transparency, accreditation, recognition as a patient centered medical home, and participation in financial incentive programs or demonstrations. Literature review reveals the common performance measures for healthcare organizations as in Table 2.1.

A performance measurement system should take care of all the indicators given in Table 2.1. The performance of healthcare organizations can be compared based on a multicriteria decision making (MCDM) technique which can consider all the criteria given above. Some examples of MCDM techniques are analytic hierarchy process (AHP), simple additive weighting (SAW), Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE), Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), ELimination Et Choix Traduisant la REALité (ELECTRE), or ViseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR).

2.3 Classification of Techniques Used in Healthcare Management

In this section, we classify HCM techniques as follows: Simulation, multicriteria decision making, mathematical programming, statistical decision making, data envelopment analysis (DEA), data mining, engineering economics, human factors engineering, structural equation model, design of experiments, system dynamics, case study, qualitative research and other approaches. Figure 2.3 illustrates the literature review results on qualitative techniques used in HCM research. This literature review is based on the search conducted in Scopus database. The keywords used are the name of the techniques and *healthcare*, which are searched in the title of the publications. The related studies under each technique are briefly given in the following.

2.3.1 Simulation

The objective of simulation is to imitate the real-world processes or systems over time, and it is based on repeated trials. A simulation model can quickly investigate the effects of a change in a real life situation that may take place over several years. It can be used to study complex systems like healthcare systems that would

Table 2.1 Common performance measures for healthcare organizations

Quality of care	Utilization-cost-efficiency	Satisfaction-reports of care	Financial performance	Others
Hospital-level mortality, complication, and infection rates	Cost per adjusted discharge	Patient-reported satisfaction	Operating revenues	Availability of foreign-language written materials
Rates of specific medical errors or other patient safety issues	Bed occupancy rate	Communication/information and consistent messages from multiple providers and wait times and ease of access	Operating expenses	Availability and ease of use of translation services
Five-year survival rates for specific cancers	Length of stay	Appearance of facilities and parking/food/other services	Pharmacy cost	Number and scope of cultural competence training program
Low birth-weight or pre-term birth rate	Patients per physician per day	Control of pain or other symptoms	Total cost per patient	Uncompensated care
Unexpected return to surgery	Nurses per service	Coordination of care	Medical cost per medical visit	Care provided in public programs
Reducing variability in clinical care	Physician per service and Patients per service per day	Respect for values and preferences	Long term debt to equity ratio and Change in net assets to expense ratio	Numbers served in free clinical service programs

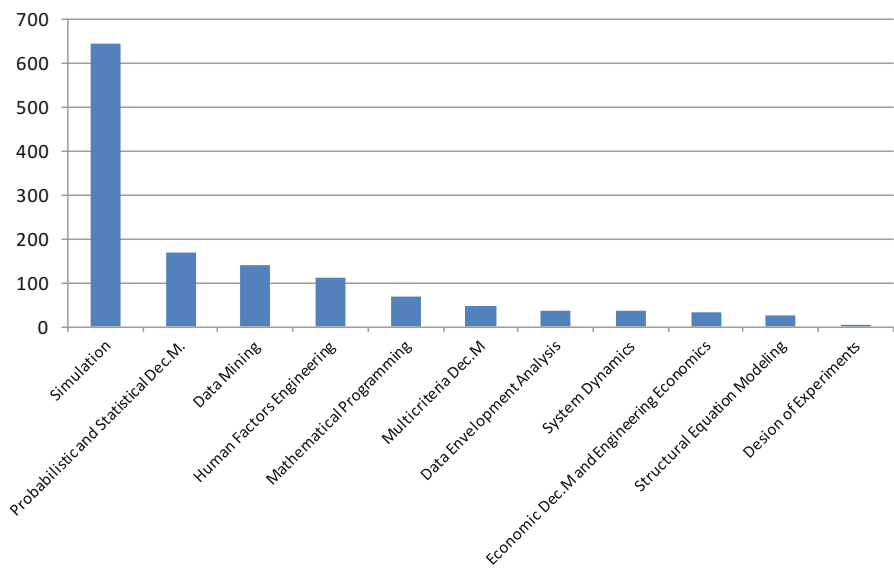


Fig. 2.3 Frequencies of qualitative techniques used in HCM literature

otherwise be difficult to investigate. However, simulation may not well model a complex multidimensional system if we do not have sufficient data to produce a mathematical model.

Simulation in healthcare is often used in safety and quality-oriented training programs, development of educational and competency assessment standards, virtual reality, epidemiologic modeling, and molecular, pharmacologic, and disease modeling. Simulation in healthcare provides a range of readily available learning opportunities, and the freedom to make mistakes and to learn from them. The learning experience can be customized, and thus, complex procedures and rare diseases can be tried by simulation training methods. Simulation also provides a detailed feedback and evaluation.

In the following, we summarize the literature on simulation-based solutions of healthcare problems.

Ramakrishnan et al. (2004) present the results of a collaborative research effort with a healthcare provider for a digital image archiving system within its radiology services. The objective is to maximize patient throughput and minimize report generation time. They build a simulation model to evaluate the different scenarios expected to ‘optimize’ the response variables. Lavy and Shohet (2007b) develop a model to adjust the allocation of maintenance resources to prevailing service conditions in healthcare facilities. The configurations integrating occupancy and environmental conditions are investigated through simulations and compared to a reference configuration. Sachdeva et al. (2007) try to combine OR methodologies

to achieve greater acceptance of results for an organizational change. Patient flow is modeled using simulation. Results from simulation, particularly for politically sensitive issues, are persuasive but inadequate to result in change. Eldabi et al. (2007) use simulation within healthcare settings based on the survey data obtained from the experts composed of academics and industrialists, a critical analysis is applied to find the differences between what exists and what could be created based on outlining some major themes. Chandra (2008) presents a healthcare supply chain template utilizing e-commerce strategy. By using simulation, optimization and information-sharing techniques are used to optimize purchasing and inventory policies. Gonsalves and Itoh (2009) propose a simulation model that contains both the subjective and objective elements in the patients' evaluation of healthcare services. The proposed model is simulated via discrete event simulation, and Genetic Algorithm is used to optimize the model. Brailsford et al. (2010) focus on the idea of combining discrete-event simulation and system dynamics and describe two practical healthcare examples of combined discrete-event simulation and system dynamics models. Gaion et al. (2009) model and simulate an alarm management system in a Colored Timed Petri Net framework to be used for testing scenarios of alarm management of healthcare devices with different levels of workload and resources. Cabrera et al. (2012) present an Agent-Based modeling simulation to design a decision support system for Healthcare Emergency Department (ED). The objective of the proposed procedure is to optimize the performance of such complex and dynamic Healthcare EDs by optimal staff configuration including doctors, triage nurses, and admission personnel. Knight et al. (2012) propose a simulation model to study the effects of patient behavior using discrete event simulation. Instead of utilizing some probability distribution for individual decisions, a decision making model is used based on system observations. The proposed model can be used for decision makers to improve overall system performance and for solving location-allocation problems. Robinson et al. (2012) utilize simulation in the implementation of lean in healthcare. The study uses both the impact of discrete-event simulation and lean approaches to the improvement of healthcare systems. Buyurgan and Farrokhvar (2015) develop a simulation model to investigate adverse events and patient safety in healthcare due to poor supply chain management practices, and inadequate and disorganized product validation procedures and compare different scenarios for patient safety, care delay, and system efficiency. Baril et al. (2016) aim at allowing a rapid and successful implementation of the solutions developed during the Kaizen. They develop a discrete event simulation to test scenarios defined by team members during a Kaizen event. Before Kaizen, some problems with the system are the limited treatment room capacities in the mornings and computerized appointment system that can schedule one treatment at the same time. Applying Kaizen, patient delays before receiving their treatment are reduced by 74% after 19 weeks.

2.3.2 Multicriteria Decision Making

MCDM is the optimum decision making process under the existence of various and conflicting criteria. MCDM is divided into two subgroups called multi-attribute decision making (MADM) and multi-objective decision making (MODM). MADM includes the techniques composed of discrete decision spaces whereas MODM includes the techniques composed of continuous decision spaces. MCDM methods are widely used in public and private sector decisions on transport, education, investment, environment, energy, defense, and so forth.

The health care industry has been relatively slow to apply MCDA. But as more healthcare researchers and practitioners have become aware of the techniques, there has been a sharp increase in its healthcare applications. Decision criteria must be weighted, and goal achievement must be scored for all alternatives. Methods of multi-criteria decision making are available to analyze and appraise multiple clinical endpoints and structure complex decision problems in healthcare decision making.

Bose (2003) presents and describes the knowledge management capabilities, the technical infrastructure, and the decision support architecture for such an HCM system and provides a decision support infrastructure for clinical and administrative decision-making. Aktas et al. (2007) propose a management-oriented decision support model to assist health system managers in improving the efficiency of their systems. The conditional dependencies and uncertainties are represented by using Bayesian Belief Networks. Zeng et al. (2013) propose an improved VIKOR method with enhanced accuracy to support the decision making in healthcare management. Dehe and Bamford (2015) compare two multiple criteria decision analysis models for a healthcare infrastructure location decision. Evidential Reasoning (ER) is used to solve the model, and Analytical Hierarchy Process (AHP) is used to compare the processes and results. Hussain et al. (2016) develop a framework to assist lean deployment in Abu Dhabi public healthcare delivery systems. Twenty one healthcare wastes are ranked based on the evaluations of local situations by experienced healthcare professionals. Marcarelli (2016) evaluate healthcare policies with benefit/cost analysis by the analytic hierarchy process. The effectiveness and efficiency of some policies and their costs are considered in the evaluation process.

2.3.3 Mathematical Programming

Mathematical programming requires the use of a computer program to make an optimum decision. It includes probability and mathematical models to solve the problems. It is one of several OR techniques whose particular characteristic is that the best solution to a model is found by optimization software. Mathematical programming enables simultaneous consideration of multiple constraints and sensitivity analysis and provides an efficient tool for healthcare professional (Earnshaw and Dennett 2003).

Rönnerberg and Larsson (2010) aim at developing an optimization tool that automatically delivers a usable schedule based on the schedules proposed by the nurses. The authors develop a mathematical model for a typical Swedish nursing ward and analyze the results. Adasme et al. (2015) develop a minmax robust formulation for routing in healthcare wireless body area networks. The proposed formulation minimizes the highest power consumption of each biosensor node placed in the body of a patient subject to flow rate and network topology constraints. The formulation includes an equivalent polynomial formulation of the spanning tree polytope to avoid having an exponential number of cycle elimination constraints and a mixed integer linear programming (MILP) formulation of the traveling salesman problem. Paschou et al. (2015) develop a personnel rostering system for healthcare units, which incorporate mobile technologies. This system minimizes the time and other bureaucratic delays in personnel scheduling.

Operating room planning is another area that OR techniques are often used. Landa et al. (2016) deal with the operating room planning problem at an operational planning level. The problem addressed consists of two interrelated subproblems usually referred to as “advance scheduling” and “allocation scheduling.” In the first sub-problem, the decisions considered are the assignment of a surgery date and an OR block to a set of patients to be operated on over a given planning horizon. The second aims at determining the sequence of selected patients in each OR and day. Roshanaei et al. (2017) aim at selecting patients with the highest priority scores and schedule them in the current planning horizon. They determine the number of surgical suites and operating rooms required to accommodate the schedule at minimum cost.

A focus in global healthcare today is on the task of improving inventory management. The main challenges in this task include uncertainty in demand and limited human resources.

Danas et al. (2006) identify the inefficiencies of the logistics systems of Greek hospitals through the management of medicine stock within the hospital pharmacy. Fortsch and Khapalova (2016) address the challenges faced by blood centers by introducing practical methods for accurate blood demand forecasting, which will allow for lowering of costs, reduction of blood wastage, and conservation of limited resources. In all locations, demand-forecasting is completed using the popular Microsoft Excel spreadsheet software; however, this field research study shows the demand for blood is non-stationary and cannot be accurately forecasted using Excel, at least not without writing a macro. Hence, they use multiple approaches to predict blood demand. At the end of the study, the Box-Jenkins methodology is shown to be the optimal choice to forecast demand. Saedi et al. (2016) develop a stochastic model to find the optimal inventory policy for a healthcare facility. They proactively minimize the effects of drug shortages under uncertain disruptions and demand.

2.3.4 *Probabilistic and Statistical Decision Making*

Statistical decision making is the process of analyzing data and using methods of statistical inference in making business decisions. Both probabilistic and statistical techniques such as statistical sampling and sampling distributions, point estimation and confidence intervals, hypothesis testing, correlations among variables and multivariate analysis are used in this process.

The capability of making statistical analyses has an extreme importance in healthcare management. Healthcare professionals generally use empirical information via statistical summaries to make decisions rather than deep data analyses. If statistical education of healthcare professionals falls short, finding the possible relations among diseases, estimation of parameters, making inferences about these parameters, multivariate analyses including clustering, factor analysis, etc. may not be possible.

Guo et al. (2008) develop a community healthcare competency scale for public health nurses (PHNs). They explore community healthcare competency of PHNs in Taiwan by using a cross-sectional research design to collect data. Chandrasekaran et al. (2012) investigate the effect of process management on clinical and experiential quality. The data gathered at various time intervals is used to statistically test the developed hypotheses. Four important implications emerge from this work. Uddin et al. (2012) measure the effectiveness of static clinic and satellite clinics to provide primary healthcare services to street-dwellers. Data collected before and after the implementation of the clinics are compared with a t-test. Vozikis et al. (2012) propose a specialized partially observable Markov Decision Process form in order to determine an optimal or nearly optimal policy for the treatment of patients with ischemic heart disease. The proposed approach has a practical advantage over clinical studies such as no risk for the life of patients and low cost. Weidmer et al. (2014) develop a system for the consumer assessment of healthcare providers for in-center hemodialysis patients. The reliability and validity of the survey are assessed with statistical methods. Van Minh et al. (2014) evaluate the primary healthcare system capacities for responding to storm and flood-related health problems by using self-administered questionnaires, in-depth interviews and focus groups discussions. Dobrzykowski and Tarafdar (2015) develop and test research hypotheses linking information Technologies. They use a paired sample of primary survey data and secondary archival data for 173 hospitals in the US. They find that increased information exchange relationship drives provider-patient communication, and increased social interaction ties drive information exchange relationship. Michailidou et al. (2015) compare the hospital charges accrued following appendectomies operations in the pediatric population. A total of 264 cases from 2007 to 2013 are reviewed, and the results indicated higher costs at laparoscopic operations. Fervers et al. (2015) examine the effects of globalization on healthcare expenditure. The research problem is whether the relationship changes

with respect to the types of healthcare systems. They analyze 22 OECD states between 1980 and 2009 in pooled time-series regressions. They find that an increase in economic openness leads to lower spending growth and to stronger in countries with social health insurance systems.

2.3.5 Data Envelopment Analysis (DEA)

Data envelopment analysis is a linear programming based technique for measuring the relative efficiencies of decision making units by employing multiple inputs and outputs. Two types of scales are used in DEA: constant returns to scale (CRS), and variable returns to scale (VRS). In CRS approach, the output changes by the same proportion as inputs are changed. In VRS approach, production technology may exhibit increasing, constant and decreasing returns to scale.

Malhotra et al. (2015) use data envelopment analysis to benchmark the performance of 12 publicly managed care organizations against one another for the period 2009–2011. They find that only six companies out of 12 are 100% efficient. They also identify the areas in which inefficient companies are lagging behind their efficient peers. Davey et al. (2015) use DEA technique by using the constant ratio to scale to compare four decision making units for the efficiencies of two private health centers of a private medical college and two public health centers. DEA technique reveals that the government health facilities group are more efficient in the delivery of primary healthcare services with respect to private training health facilities group.

2.3.6 Data Mining (DM)

Data mining is the process of analyzing and discovering patterns in data by using different perspectives such as artificial intelligence, machine learning, statistics, and database systems. It aims at extracting information and transforming data into an understandable structure for further use.

DEA enables using multiple inputs such as the number of beds, doctors and nurses and outputs such as patient days and total immunization for measuring the performance of healthcare systems. In some of DEA applications, the weights of inputs and outputs can be defined (Al-Shayea 2011).

Huang et al. (1995) propose an agent-based system in order to help manage the care process in real-world settings by combining artificial intelligent and agent techniques. Swangnetr et al. (2010) compare two simulated robot medicine delivery experiments with different participant age groups and robot configurations by using a meta-analysis of data and statistical and machine learning methods. Utter et al. (2010) conduct a retrospective cross-sectional study including 11 indicators from 18 geographically different academic medical centers based on the medical records using a standard instrument and descriptive analysis. Darrel et al. (2014) present a

literature review on the quantifiable and measurable benefits of big data analytics in healthcare systems. The main advantages of big data analytics usage are obtained in the improved outcomes for patients and lower costs for healthcare providers. Ramírez-Ríos et al. (2015) examine DM algorithms as a feasible and necessary strategy for optimal management of databases (DB) in the national healthcare systems. They deal with the management of multiple DB that considers patient's affiliation information under the supervision of the authorities in healthcare. Their DM analysis detects frauds and other type of duplicities.

2.3.7 Economic Decision Making and Engineering Economics

Engineering economics is the science of giving economic decisions based on discounted cash flow techniques such as present worth analysis, annual worth analysis, the rate of return analysis, etc. Time, cash, and interest are the three parameters of engineering economics. The economic analysis methods can also be used under risk and uncertainty conditions.

Through better healthcare system design and capital investments in new health technologies, such as electronic medical records, telemedicine, and imaging systems, healthcare managers can manage disbursements and benefits. The time value of money can be considered through engineering economics science, and thus correct economic decisions can be made. Sensitivity analysis should be conducted before giving risky investment decisions since health technologies are too expensive. Multiparameter sensitivity analysis rather than one-at-a-time sensitivity analysis should be applied to analyze the effects of changes in two or more parameters.

Johnson (2008) develops some spreadsheet functions that enable queuing theory in healthcare systems. The proposed functions can be used for better process understanding leading to better decision making and optimization of the healthcare budget. Dortland et al. (2013) reveal the position of real estate departments through an exploratory survey among health organizations. They consider the type of project coalitions and the rationale behind this choice and the flexibility regarding a real option. Devaraj et al. (2013) examine information technology investments among hospitals and how it influences patient care and financial performance with an operations management-based perspective on the effect of IT in streamlining hospital operations. Zadeh et al. (2015) describe a framework that can facilitate the implementation of evidence-based design (EBD), and clarify the related safety and quality outcomes for the stakeholders. They use engineering economy tools including present values, internal rates of return, and payback periods to evaluate the return on investments, in which facility design and operation interventions resulted in reductions in hospital-acquired infections, patient falls, staff injuries, and patient anxiety.

2.3.8 Human Factors Engineering

Human-factors engineering is the science that deals with the application of information on physical and psychological characteristics to the design of devices and systems for human use. In order to provide safety, effectiveness, and ease of use, human factor engineering focuses on both human strengths and limitations in the design of interactive systems.

Human factors engineering has recently been used in healthcare management to increase reliability, especially in the operating room. Human factors engineers test new systems and equipment under real-world conditions in order to identify potential problems and unintended consequences of new technology. These usability tests can be applied to various healthcare management problems such as data and information processing.

Boston-Fleischhauer (2008) uses human factors engineering and reliability science for enhancing existing operational and clinical process design methods in healthcare. Van De Weerd and Baratta (2012) focus on analyzing working conditions of home healthcare services, which is a growing service area in Europe, such as aides and nurses. The authors analyze the impacts of home healthcare works regarding job satisfaction, well-being, emotions at work, relationships with the others and occupational stress.

2.3.9 Structural Equation Modeling (SEM)

Structural equation modeling is composed of a diverse set of mathematical models, computer algorithms, and statistical methods such as confirmatory factor analysis, path analysis, and partial least squares path analysis that fits networks of constructs to data. SEM can deal with measurement error, enables examining, and modelling complex healthcare problems (Beran and Violato 2010).

Gowen et al. (2006) examine healthcare quality program practices, employee commitment, and control initiatives, and perceived results based on the responses from Quality and Risk Directors of 372 U.S. hospitals. The results of SEM indicate that both quantitative and qualitative quality program results are mainly related with employee commitment and control initiatives. Haggerty et al. (2011) compare how well accessibility is measured in four different subscales that evaluate primary healthcare from the patient's perspective based on SEM analysis. They use the results of a survey of 645 adults with at least one healthcare contact in the previous 12 months.

2.3.10 Design of Experiments (DOE)

The design of experiments deals with the determination of the relationship between factors affecting a process and the output of that process. The primary purpose is to find cause-and-effect relationships between the process inputs and outputs. DOE techniques are commonly used in clinical evaluations but their usage in the production and design phases are limited. Designing effective experiments increases the reliability and efficiency of healthcare management.

Ramakrishnan et al. (2005) focus on identifying appropriate modifications to the existing workflow at the computed tomography (CT) scan area of a healthcare provider while transitioning from a film-based image archiving system to a digital system. Apart from the workflow, the flow of information also needs to be modified and streamlined. The ultimate goal is to maximize patient throughput and minimize report generation time. Industrial engineering tools such as process mapping and time study are used to understand the initial flow of operations. A Design of Experiments based approach is used to identify the effect of the variables in the system and the interaction amongst them. Modeling and simulation are used to analyze and quantify the potential benefits that can result from the implementation of the digital image archiving system. Savsar and Al-Ajmi (2012) determine the significant factors that cause delays in surgery operations and affect the productivity of surgery clinics in a hospital. Based on data collected from surgery clinics of an international hospital, design of experiment approach is used to determine the significance of the effects of the factors.

2.3.11 System Dynamics

System dynamics aims at understanding the nonlinear behavior of complex systems over time based on flows, internal feedback loops, and time delays. It is a computer-aided approach applied to dynamic problems arising in complex social, managerial, economic, or ecological systems. It first defines problems dynamically and proceeds through mapping and modeling stages. System dynamics enables modeling complex healthcare problems such as multiple interacting diseases, supply chain problems, and expansion of diseases (Homer and Hirsch 2006).

Lane et al. (2000) develop a system dynamics model of the interaction of demand pattern, resource deployment, hospital processes and bed numbers. They find that some delays to patients are unavoidable and reductions in bed numbers do not increase waiting times for emergency admissions. Brailsford (2008) illustrates several examples of system dynamics in healthcare organizations and discusses the possible reasons for the popularity of system dynamics for healthcare modeling. Samuel et al. (2010) analyze health service supply chain systems using system dynamics, where three service stages are presented sequentially. Zamora Aguas et al. (2013) develop a system dynamics model in order to assess supply risk impact

in the oncological medicine supply chain in Colombia. Supply networks, supply chain costs, improving service, quality and opportunity performance indexes are included into the model. Rich and Piercy (2013) develop a systems dynamics model of hospital healthcare in order to capture the problems in the existing system and their inter-relationships.

2.3.12 *Qualitative Approaches*

Qualitative methods are used to gain an understanding of primary reasons, opinions, and motivations about research problems. Qualitative research is also used to uncover trends in thought and ideas, and exhibit details about the problem. Some standard qualitative approaches include focus groups, individual interviews, and participation/observations.

Qualitative approaches are relatively rarely used in healthcare management but they add significant value to healthcare management. Especially, social and cultural aspects of healthcare management can be revealed with qualitative research. Qualitative approaches provide important insights into health-related phenomena, generating new ways for empirical questions. Qualitative research is based on health related lived experiences and relational processes as the basis of social phenomena.

Finstuen and Mangelsdorff (2006) identify the mentoring and executive competencies required among preceptors of a graduate program in health and business administration. They specify the requisite skills, knowledge, and abilities needed to achieve those competencies by using a Delphi methodology through e-mails. Hunt (2009) focus on relief operations and aims at exploring the moral experience of Canadian healthcare professionals during humanitarian relief work. The authors conduct 18 semi-structured individual interviews based on Interpretive Description methodology. Bauernschmitt and Conradie (2010) establish a descriptive research to present to what extent private healthcare providers have contemporary knowledge and understanding of supply chain practices and what extent these providers adopt and apply such knowledge to recognized practices and concepts. Farinella et al. (2011) describe the outcomes of a case study on the regional differences in implementation of “stroke networks” in Italy, which is one of the most important health issues in Italy. The results of 52 in-depth interviews and six focus groups indicate that early diagnosis, delivery of treatment and rehabilitation therapy can reduce the risks of death and disability. Papadopoulos et al. (2011) conduct a qualitative study in order to explore the dynamics in the implementation of a process improvement methodology using actor-network theory. They illustrate the utility of actor-network theory in articulating the dynamic nature of networks underpinning socio-technical change. Nelson (2011) presents a descriptive study and describes the perceptions of staffing adequacy of healthcare team members working together after conducting semistructured interviews in a cancer center. Hadziabdic et al. (2011) focus on exploring the problems reported by healthcare professionals in primary healthcare concerning the use of interpreters and what the problems lead

to. The authors use qualitative content analysis of 60 real-life incident reports to find out the major problems. Jaafaripooyan et al. (2011) identify performance measures to evaluate accreditation programs in healthcare based on qualitative methods, including snowball sampling technique, email interviews, and thematic content analysis.

2.3.13 Other Approaches

Some healthcare management papers cannot be classified with respect to the above-mentioned approaches. We categorize these works as follows:

2.3.13.1 Cost Analysis in Healthcare

Nicholson et al. (2004) focus on inventory costs and service levels in a healthcare organization. The authors compare two models, three-echelon distribution network managed by the healthcare organization, and two-echelon distribution network outsourced to a third party, for non-critical inventory items. The results indicate that outsourcing distribution of non-critical medical supplies reduce inventory cost savings while service levels are not changed.

2.3.13.2 Quality in Healthcare

Dey and Hariharan (2006) propose a model for identifying problems and evaluating the performance of healthcare services. The authors apply the model, logical framework analysis in three services of a hospital and show the effectiveness of the proposed method with the case study. Mohammadi et al. (2007) suggest a quality based outline for a customer-driven health system. The authors determine six types of customers, nine types of outputs and the various operations associated with them. De Mast et al. (2011) focus on healthcare processes in order to provide a unifying and quantitative framework. In their proposed methodology, the authors integrate the various process improvement approaches such as six sigma, lean thinking, and total quality management in order to provide conceptual models and practical templates for diagnosis in healthcare processes. Culcuoglu et al. (2012) propose a modified Kaizen approach that utilizes a series of two to four hour Kaizen Sessions for healthcare delivery systems. The authors also present how to document and measure the success of the sessions' effect.

2.3.13.3 Information Technologies in Healthcare

Lubitz and Wickramasinghe (2006) propose an integration of information technologies into healthcare operations. The proposed network-centric healthcare operations support system provide information flow among all users of the system and enable relevant knowledge to be generated and exchanged among the users. Later, Von Lubitz et al. (2008) extend the network-centric approach and give a new definition of Worldwide Healthcare Information Grid which is a global system for the efficiently conducting of healthcare operation around the world. Kuan (2009) proposes an RFID integrated healthcare system. The proposed service management system can handle operations such as revenue management, expenditure, service timing and provide analytics for managerial decision. Machado et al. (2010) focus on Ambient Intelligence based monitoring techniques in healthcare environments. They address the different methodologies put into operation in the healthcare sector, supported by a putative architecture which is used in various healthcare institutions to support RFID monitoring systems. Wu et al. (2011) suggest a remote healthcare platform for people with chronic disease living at home or inpatients living in the hospital. The proposed approach is based on open service platform and aims to overcome integration problem and improve ease of use. Shie et al. (2011) focus on electronic health information system and information exchange and give insight into the architecture, potential benefits, and challenges. The authors also present the current state of the applications while providing insight on the future research by highlighting the difficulties and potentials. Simonen et al. (2012) define the information concerning factors that promote the use of effectiveness data in healthcare management. The results show that the use of effectiveness data in healthcare management can be limited due to research, managerial work, and the organization. Grandinetti and Pisacane (2012) analyze the web services for healthcare management, and use operations research approaches in order to increase the effectiveness of the web services. Lillrank (2012) presents a definition of integration and coordination in health service production. The author identifies purposes, contexts, and design rules for integrated healthcare by applying a design science methodology. Chen (2012) integrates geographic information system, radio frequency identification and grid computing technology to provide an information system which can monitor and detect infectious events. Bhagya Lakshmi and Rajaram (2012) examine the impact of innovative approaches and information technology applications on the acceptance of rural healthcare services. Data is collected from 465 rural health personnel and analyzed statistically.

Liu and Park (2013) define the challenges and requirements of an e-Healthcare interconnection infrastructure and provide a framework. In their design, the authors take into account dimensions such as; security, integrated service management, on-demand access to the network, quality-of-service, accounting. Shi et al. (2013) investigate electronic health record systems and health information exchange by presenting their architecture, benefits, challenges, and other related issues. Lucas et al. (2013a) examine the relationship between facility management and healthcare delivery. A case study is used to define different types of information needed to

perform maintenance tasks satisfactorily. Lucas et al. (2013b) propose a healthcare facility information management prototype, which allows facility managers to respond more efficiently and effectively to facility related events. Sobol and Prater (2011, 2013) analyze healthcare practices of two countries, the United States and Taiwan, in order to provide a formal benchmark of information technology usage. The authors compare the countries regarding adaptation of information systems and the efficiency created by the usage. Banerjee et al. (2013) propose an architecture of a cloud-based healthcare application intending to serve patients in emergency conditions. Under the emergency, the patient's medical history can be tracked by the cloud system and better decisions can be given. Healthcare management is an important interest area of supply chain management literature. Chen and Chang (2013) propose using RFID technology to produce a healthcare monitoring system which can trace every event the same times as the events happen. The applicability of the system is demonstrated in a pilot study. Ker et al. (2014) focus on the efficiency of logistic systems of medicals and evaluate the effectiveness of information systems used in pharmacies. Browne et al. (2015) focus on primary healthcare organizations. The authors summarize innovative intervention called EQUIP which designed to improve the capacity of primary healthcare clinics. The authors also provide information about real-world examples from four different clinics, which adopt the intervention.

2.3.13.4 Tactical and Strategic Decision-Making in Healthcare

Lavy and Shohet (2007a) develop a decision-making model which can integrate various parameters into a facility management tactical and strategic decision-making process. In the study, the authors provide the architecture and procedures of the proposed model.

2.3.13.5 Lean Management in Healthcare

Enache-Pommer and Horman (2008) integrate lean approach with green principles and apply them in children's hospitals. The results of the application of the proposed approach in three hospitals show that with the proposed approach the hospitals may become more efficient and healthful. Hicks et al. (2015) provide a case study on applying a lean approach to production, preparation, and process (3P) to design a new endoscopy unit in England. The result of the analysis shows that this 3P participative design method is an effective tool for meeting the requirements of multiple stakeholders. Healthcare management uses the principles of system analysis and design.

2.3.13.6 Environmental Management in Healthcare

Kagioglou and Tzortzopoulos (2010) examine the business flow of healthcare infrastructure sector from a built environment perspective. The authors give insight into the trends in healthcare, explain the alternative models of healthcare delivery; current building and investment programs; clarify the procurement process, and describe facilities management activities, give details about related financial models, risk evaluation on healthcare. De Fátima Castro et al. (2015) propose a benchmarking approach for healthcare buildings. The authors take Building Sustainability Assessment methods as a baseline and try to reduce the subjectivity given in the definitions. As a result, the authors define criteria for healthcare buildings in four main groups namely, consumption of resources, waste production, costs and environmental impacts.

2.3.13.7 Risk Analysis in Healthcare

Sørup and Jacobsen (2013) focus on employee absence in the healthcare sector. The authors initially define the main factors of employee absence using satisfaction scores, and then they use these findings to form a management framework, which provides information about risk factors associated with employee absence. Technology management is also an important aspect of healthcare management.

2.4 Conclusions

In this chapter, we reviewed the literature review on healthcare management. The review results can be classified as follows: the works on quantitative and qualitative techniques in healthcare management; the works on healthcare case studies; and the works on healthcare literature reviews. We later classified the techniques and approaches used in healthcare research and gave some related recent papers under each class.

The common aims of the HCM studies in the literature can be classified as the quality of health care, efficiency improvement, patient satisfaction and financial performance. Literature review reveals that quantitative techniques are more frequently used than qualitative techniques in HCM. Within quantitative techniques, the most commonly used ones are simulation, statistical decision making and data mining. The common feature of these techniques is that they are data driven.

Data analysis is a critical component of healthcare management works. Data analysis has gained acceleration in the recent years from data mining to big data. Especially, with the emergence of IOT (internet of things) technologies, new sources

of data related to healthcare management are included in these studies. For instance, IOT and Big Data technologies will provide improved patient care, flexible patient monitoring, and improved drug management. These emerged technologies will take an important place in the future of HCM research areas. Hence, we suggest data mining and big data analyses to be utilized in healthcare for further studies.

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