

Table S1 Identified studies focused on the use of AI for strategic decision-making in hospitals

Citation	Setting/context	Application	Use	Type of AI	Evaluation
Review articles					
Eom & Kim 2006 (6)	Not specified	Third literature review of decision support systems (DSS) from 1995 to 2001	In healthcare DSSs were operationally focused to improve patient admission, discharge and billing, collaborative medical decision-making, scheduling nurses, improve material management processes, control sexually transmitted diseases, and track indicators of mental health providers' productivity	AI decision support systems	N/A
Broekhuizen <i>et al.</i> , 2015 (27)	Literature review of SCOPUS and PubMed from 1960–2013 for multi-criteria decision analysis (MCDA) to identify models to address uncertainty for application to healthcare decision-making	Identified five methods: Bayesian framework, deterministic sensitivity analysis, probabilistic sensitivity analysis, fuzzy set theory and gray theory	Identified 7 papers using MCDA for health policy decisions. Four studies used deterministic sensitivity analysis, two used probabilistic sensitivity analysis and one used fuzzy set theory	Deterministic most appropriate if the criteria weights are varied as a single value. Gray approach most appropriate if only lower and upper bounds are used. In a group decision process where the opinions of several decision-makers are combined, the probabilistic and fuzzy set approaches allow distributions	N/A
Duan <i>et al.</i> , 2019 (5)	Review of papers published in International Journal of Information Management	History and development of AI	Identified 52 substantive papers; mostly used in manufacturing, health care and legal practice. 12 research propositions in theory development, technology-human interface and AI implementation	Greatest AI type was rules-based, with change from humans identifying rules to machines identifying the rules	N/A
Shahid <i>et al.</i> , 2019 (9)	Scoping review	Scoping review of ANNs in healthcare organisational decision-making	18% of 80 articles were classified as organisational behaviour and included: behaviour and perspectives, crisis or risk management, clinical and non-clinical decision-making, and resource management. Only 10 studies could be considered as strategic application	Supervised data-driven	N/A
Descriptive studies					
Hedelin & Allwood, 2002 (13)	Public and private sector organisations in Sweden with three public hospital participants	Interviewed 41 senior managers on use of information and communications technology (ICT) for strategic decision-making	Wanted user friendly systems they could use that extracted information from various databases into an analytic database that could complete all statistical analysis. Needed to obtain trustworthy data more easily and quickly	N/A	N/A. Concerned that it would not be possible to use ICT to a greater extent in strategic decision-making without inappropriate simplification and standardisation
Yang <i>et al.</i> , 2013 (28)	Two hospitals in Asia	Case studies	Tracked the decision process to implement wireless vital sign monitoring systems. Found eight enabling factors, with issue driven and clinical trigger factors influencing a stronger organisational mandate, with centrally-led more connected senior champions and project team members, vendor alignment with resources shared throughout the organisation, appeared to influence a better pilot outcome	Data-driven	N/A. Not strategically focused, as the case studies explored a local clinical application, but results may be relevant for AI implementation for strategic decisions making
Application articles					
Fala <i>et al.</i> , 1995 (35)	Not specified, but focused on cost and utilisation reduction in USA health system	Describes four expert systems: INFER, PsychINFER, Procedure Necessity, and Alternatives to Non-Surgical Admissions (ANSA) using a classic knowledge engineering approach	INFER and PsychINFER help to identify potentially catastrophic or chronic cases so that they may be aggressively managed. Procedure Necessity helps to decide whether a surgical or diagnostic procedure is necessary on a case-by-case. The systems advise specialists, who use their own judgement	Rule-based system	Authors suggest, but do not provide analysis of, greater return on investment in case management, reductions in inappropriate referrals, and greater consistency in decision-making
Forgionne and Kohli, 1996 (29)	Evaluated by students at Johns Hopkins University, University of Baltimore and health professionals at Saint Joseph Hospital, USA	Hospital Management Support System (HMSS)	Provides integrated clinical and administrative data to assist concurrent engineering, which, although focused on operations, was suggested would help hospitals achieve their strategic objectives	Knowledge-based	Evaluation with control group using standard StratPlan DSS and experimental group using HMSS for a planning exercise, which suggested HMSS provided greater maturity in decision-making and better performance
Abidi, 1999 (30)	Not specified	Theoretical description of a Strategic Knowledge Services Info-structure	Gathering information from a variety of existing healthcare databases to make strategic decisions on service capacity, costs, policy and planning	Knowledge-based	No evaluation
Edmonds & O'Connor, 1999 (62)	Emergency departments in South Eastern Ontario Health, Sciences Centre, comprising public hospitals in Kingston, Canada	Discrete-event stochastic computer simulation using MS Access	Model changes to ED performance (occupancy, workload, length of stay) by manipulating ED capability, hours, staffing profile	Knowledge-based	Three scenarios for hospital restructuring were completed, but there was no evaluation of the accuracy of the simulation results
Moreno <i>et al.</i> , 2000 (32)	Not specified- aimed for use by hospitals	Computer simulation using discrete event algorithm	Track hospital patient flow to enable testing of various strategies to assist decision-making	Expert system	No evaluation
Moreno <i>et al.</i> , 2001 (33)	Not specified	Theoretical description of how domain and control knowledge is included in a knowledge-based system (KBS) using KADS to be used for hospital management monitoring, diagnosis, prediction and design	Possible solutions obtained during the prediction task are used to build a solution where all management problems detected in the system can be solved	Knowledge-based	No evaluation
Ramani, 2004 (31)	Three general hospitals administered by Ahmedabad Municipal Corporation (AMC), India	Describes the performance indicators of a management information system incorporating data from various parts of the hospital. Also describes aspects of the implementation process	Generates estimates of a limited set of hospital performance indicators	Knowledge-based	No evaluation
Mousakhani <i>et al.</i> , 2010 (36)	Five hospitals in Iran	Used fuzzy logic in Analytical Hierarchical Process (AHP) to compare the published strategic balanced scorecards of five hospitals	Four scorecard perspectives and 16 performance indicators were ranked in pairs in relation to the strategic objective to enable ranking of the hospitals	Model-based	No evaluation
Aktaş <i>et al.</i> , 2007 (37)	Radiology department of a private hospital in Turkey	Bayesian Belief Network (BBN)	Provides a picture of current resource utilisation in a process and identifies potential strategies to improve resource utilisation	Probabilistic reasoning	No evaluation
McClean and Millard, 2007 (39)	UK NHS system comprising hospital, patient's home, residential home, nursing home and death with rehabilitation and prosthetic service models	Markov reward model	Cost the movement of older patients within a healthcare system. Illustrated that keeping patients longer in hospital, improving their fitness for discharge can reduce transfer of patients into secondary care systems and may both improve hospital performance and reduce costs	Probabilistic reasoning	No evaluation, as authors indicate it is difficult to get accurate data
Fernández & Ossowski, 2008 (34)	Not specified	Describes the development of a Service-Oriented Multi-Agent System (SOMAS) that uses organisational information on roles of agents and the interactions among these agents in the provision of services to model service coordination	Provides matches of services and service providers to the defined needs, that is most effective with the use of a role-based filter	Knowledge-based	Was evaluated against an existing service matchmaker and the addition of the roles and interactions in SOMAS was found to outperform in efficiency and effectiveness of the matches
Nunes <i>et al.</i> , 2009 (40)	Not provided	Markov decision process involving patient demand, treatment patterns and hospital resources	Modelling elective hospital admissions by speciality	Probabilistic reasoning	No evaluation
Malliaris & Pappas, 2011 (43)	Hospital foundations in the USA	ANN with information on campaigns and events obtained from websites and financial information from non-profit reporting	Predict the fundraising revenue arising from different fundraising strategies	Supervised data-driven	Comparison of ANN and multiple regression model found greater accuracy with ANN
Eswaran & Logeswaran, 2012 (42)	Population health data, such as birth rate, mortality from tuberculosis for Indonesia	ANN in combination with linear regression	Predict the three population health indicators using the model and compared to actual and analyse the effect of management decisions	Supervised data-driven	Predicted indicator values were close to actual values
Cohan <i>et al.</i> , 2017 (48)	Unidentified hospital data from USA	Convolutional and recurrent neural networks	More efficiently capture narratives of patient harm	Supervised data-driven	Performed better than existing methods in identifying patient harm using two datasets with 76,752 patient incident reports
Tafti <i>et al.</i> , 2017 (49)	Structured and unstructured text data from scientific publications and social medias on the Internet	Machine learning was used to collect evidence of the impact of adverse medical drug events associated with 28 prescribed drugs	Efficiently summarise text-based clinical findings in extremely large databases	Supervised data-driven	Outperformed physical collection by trained researchers
Wang <i>et al.</i> , 2018 (50)	Barnes-Jewish Hospital, USA	Cost sensitive (convolutional) deep neural network algorithm (CSDNN)	Predict hospital readmissions	Supervised data-driven	Algorithm was evaluated using existing datasets and performed better than baseline on two indicators
Erdoğan <i>et al.</i> , 2019 (41)	UK National Health Service Trust	Excel-based Decision Support System for Facility Location Problems using a Tabu Search algorithm and linking to a Geographic Information System	Evaluate current maternity services model and provide analysis to determine opening, closing, relocating maternity services	Data-driven	While recommendations were accepted for implementation, this has not been evaluated
Sun & Medaglia, 2019 (38)	Zhejiang Provincial Hospital of Traditional Chinese Medicine in China	Identified challenges to implementation of AI to design individual treatment plans	Poses natural language questions to design a treatment plan	Probabilistic evidence-based	Study found social, economic, ethical, political, data, technological and of most relevance organisational and managerial challenges. These include lack of AI strategy, tension between data integration, and interests of individual organisations in keeping the data, lack of competent workforce, fears of workforce substitution and lack of trust of AI decisions

AI, artificial intelligence; ANN, artificial neural network.