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Application of soft operations research methods in healthcare: A systematic review

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Abstract

The purpose of this systematic review is to identify and categorize the application of soft operations research methods in healthcare settings. A systematic review was conducted to identify published papers on the application of soft operations research methods in the healthcare setting, using Google Scholar, Scopus, PubMed, Emerald, Elsevier, Web of Science, and ProQuest databases through December 2021. A total of 69 papers met our selection criteria for the systematic review. Soft operations research methods were used in a wide range of healthcare fields, including healthcare management, health informatics, e-health, and medical education, for identifying requirements, problem-solving, system design and implementation, process improvement, policymaking, knowledge management, and managing resilience, and marketing. This study contained restrictions on access to the full text of some articles and dissertations that had little impact on the study's quality. The present study demonstrates the use of soft operations research methods in various areas of the healthcare system to better understand problematical situations. This paper can help to use soft operations research methods further in the healthcare problems, especially in the design and implementation of e-health and emerging new technology.

Keywords: soft operations research; Problem structuring methods; healthcare; tackling complexity; systematic review.

Paper Type: Review Research

1. Introduction

Healthcare is becoming increasingly complex in all disciplines, at all levels, and the worldwide (Plsek PE et al.,2001). Healthcare is an example of a complex adaptive system (CAS) (Braithwaite Jet al.,2017). A complex adaptive system is a collection of individual agents with the freedom to act in ways that are not always wholly predictable and whose actions are interconnected so that the action of an agent changes the context for other agents (Plsek PE et al.,2001). Healthcare has a range of different stakeholders such as citizens, taxpayers, politicians, policymakers, providers, managers, doctors, patients, and patient groups. It also includes the public and private sectors and provides care in many settings and through a variety of organizations, for example, public health settings, community centers, hospitals, nursing homes, and family or public practices. The individuals who provide care, and the groups, teams, networks, and organizations through which they provide services, interact in complex configurations, longitudinally (Braithwaite Jet al.,2017). Complex systems have fuzzy borders; their interacting agents operate according to internal rules that cannot always be predicted; and they adapt, interact and evolve together with other systems. The critical point is that complexity is a system's feature, not just an intervention characteristic.

Whether an intervention is simple (one active component, unchanging) or complex (multiple interacting components), the system in which the intervention is carried out will almost consistently need to adapt in some way to accommodate it (Greenhalgh Tet al.,2018).The term complexity is often used in the scientific literature to define tasks or systems ranging from complicated to intractable, with a general meaning of not simple (Kannampallil Tget al.,2011). Complexity is described as a dynamic and constantly emerging set of processes. objects that interact with each other and come to be defined by those interactions (Cohn Set al.,2013). In complexity thinking, many of the classical, step-by-step, scientific approaches to problem-solving and engendering change, which focus on breaking down problems into discrete parts, implementing standardized solutions, and controlling for contextual variables, are not effective. At present, more than ever, approaches to healthcare improvement are required that identify the complexity of context and the various interests and understandings of a problem held by different stakeholders (Augustsson H et al.,2020).Problem structuring methods (PSMs) are qualitative approaches for making progress with ill-structured problems (Smith CM et al.,2019). Characteristics of unstructured problems include: multiple actors, multiple perspectives, incommensurable or conflicting interests, important intangibles, and key uncertainties (Mingers J et al.,2004).

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Nature of a problem and classifying it as belonging to one of three categories: puzzles, problems, and messes. For each category, appropriate problem-solving approaches are suggested and practiced (Matthee M et al.,2019).
Ackoff (Ackoff RL,1978) categorized problems in terms of their complexity. The puzzle is a situation with no ambiguity. There are clear rules to follow to arrive at a solution, there is only one solution, and it is possible to know that one has arrived at the correct answer. Many problems in the mathematical field can be classified as puzzles.Problems are more complicated than puzzles since multiple possible solutions depend on circumstances, constraints, and assumptions. The field of operations research is concerned with methods to address problems in the real-world context. Messes are to the contrary extreme of the puzzles in that they are ill-structured. In messy situations, it is ambiguous to know what the problem is that needs to be resolved, let alone what process to follow. Messes are also known as wicked problems and are characterized by uncertainty, complexity, and several views on the situation by the various stakeholders. A specialized study field in resolving messes is known as soft operations research (Matthee M et al.,2019).In the past decades, new approaches and methodologies have been developed to solve unstructured and messy problems with various stakeholders. These methods have a precise structure and clear framework, are often categorized as soft operations research or problem structuring methods. Research methods on soft operations research are rooted in soft system thinking and belong to the interpretative/learning paradigm (Sepehrirad R et al.,2015)Soft operations research mainly uses qualitative, rational, interpretative, and structured techniques to interpret, define, and explore diverse prospects of an organization and the problems under consideration. They generate discussion, learning, and understanding, and use it to progress through complex problems (Heyer R,2004).Among these methods, soft systems methodologies (SSM), cognitive mapping (CM), strategic options development and analysis (SODA), Interpretive structural modeling (ISM), and strategic choice approach (SCA) are specifically worthy of being heeded (Ferreira Js,2013).Soft systems methodology (SSM) is an approach to tackling problematic and messy situations of all kinds. It is an action-oriented investigation process in problematic situations in which users learn their way of discovering the situation, to take action to improve it. Participants build ideal-type conceptual models, one for each relevant world view. They compare them with perceptions of the existing system to generate debate about what changes are culturally feasible and systemically desirable (Checkland P et al., 2010).Cognitive mapping is a technique used to structure, analyze and make sense of problems. Cognitive mapping, a form of influence diagram, has been used by a variety of researchers in a variety of settings. Cognitive maps provide a holistic picture of an individual's overall perspective, without the loss of any detail, also enabling researchers to move beyond the assumption of internal consistency to the detailed assessment of specific concepts within the map (Ackermann F al.,1992).Strategic options development and analysis (SODA) is a general method of identifying problems that enables a group or individual to build a graphical representation of a problematic condition. So, explore options and their ramifications concerning a complex system of goals or objectives. SODA uses cognitive mapping as a modeling device for eliciting and recording individuals' views of a problem situation. The merged individual cognitive maps provide the framework for group discussions, and a facilitator guides participants towards commitment to a portfolio of actions (Ackermann F et al,.2010).Interpretive structural modeling (ISM) is an interactive learning process for identifying and summarizing relationships among ideas and imposing structure on the issue's complexity. In this method, a collection of different directly and indirectly related components are structured into a comprehensive systematic model. Also, Interpretive structural modeling is a computer-aided method for helping groups develop graphical representations of complex systems (Watson RH,1978).Strategic choice approach (SCA) is a planning approach centered on managing uncertainty in strategic situations. Facilitators assist participants in modeling the interconnectedness of decision areas. Interactive comparison of alternative decision schemes helps them to bring key uncertainties to the surface. On this basis, the group identifies priority areas for partial commitment and designs explorations and contingency plans .

2. Research methodology

The objective of this research was to identify and categorize the application of soft operations research methods in healthcare settings. Two questions were raised for this purpose.
RQ1: In which field of healthcare have soft operations research methods been used?
RQ2: What kinds of soft operations research methods are used in the healthcare settings?
Relevant studies were identified through electronic searches of Google Scholar, Scopus, PubMed, Emerald, Elsevier, Web of Science, and ProQuest databases through December 2021. The keywords used in this search were Soft Operations Research, Problem Structuring Methods, Soft Systems Methodology, Cognitive Mapping, Strategic options development and analysis, Interpretive structural modeling, Strategic choice approach, Healthcare System, medical system, health informatics, medical informatics, health information system, e-health, telehealth, telemedicine, complexity, complex system.
This study contained restrictions on access to the full text of some articles and dissertations that had little impact on the study's quality. Inclusion criteria in this study include the following: articles and dissertations should have an abstract and full text, be peer-reviewed and be published in English. In these papers, soft operations re-

search methods were used as the main research method or in combination with hard operations research methods. Finally, the research setting was in the field of healthcare.
As a next step, information was extracted from the research papers. A total of 9 data items were extracted from each article. The data items include Title, Year of publication, Author(s), Method(s), Study setting, Aim of study, Article Type, Journal, and Country of origin for study.

3. Finding

This section presents the results of the systematic review. Figure.1 illustrates the process flow diagram of identification, screening, eligibility, and inclusion of articles for the systematic review, using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework.
A systematic search of Google Scholar, Scopus, PubMed, Emerald, Elsevier, Web of Science, and ProQuest databases yielded 938 articles, and later nine articles were added from the references list. After deduplicate articles, 933 remaining studies were screened based on titles and abstracts, and 825 records were further excluded. The remaining 108 studies were screened by critically reading the full texts. Of the 108 full-text studies, we excluded 39 studies. In the end, a total of 69 articles met our selection criteria for the systematic review of application of soft operations research methods in healthcare.
In 69 selected studies, there were 63 (%91.3) research articles, two (%2.9) master thesis, and four (%5.8) Ph.D. dissertations. These studies were published between 1994 and 2021, with five studies (%7.2) in the 1990s, 21 studies (%30.5) in the 2000s, 33 studies (%47.8) in the 2010s, and ten studies (%14.5) by 2021. (Figure.2)

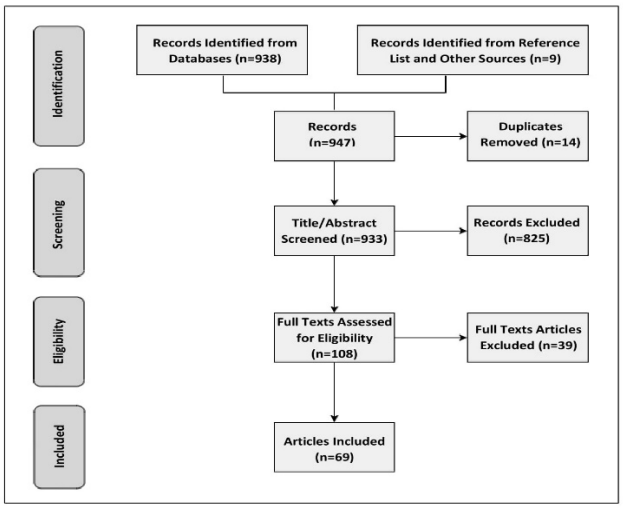

Figure 1: PRISMA Flow Diagram

The soft operations research method used in 55 articles (%79) was soft systems methodology (SSM), 12 articles (%17) used cognitive mapping (CM) method, and three articles (%4) used interpretive structural modeling (ISM). In one article, a combination of SSM and ISM methods is used (Figure.3)

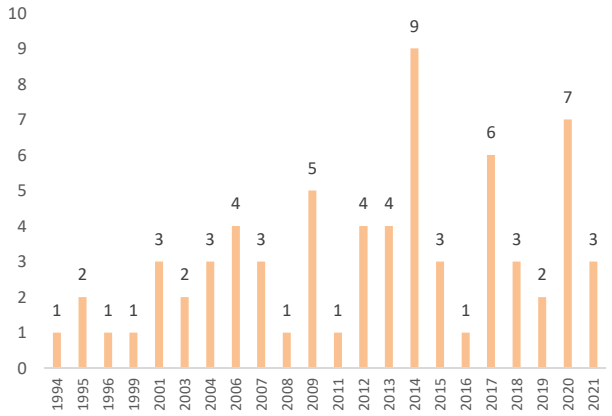

Figure 2: Frequency of publication during 1994-2021

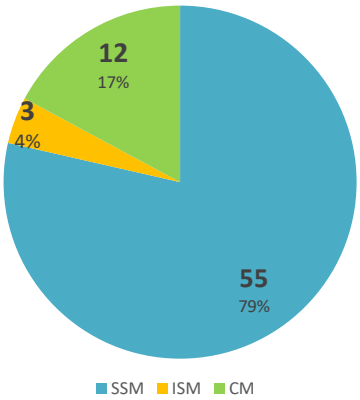

Figure 3: Frequency of soft operations research methods

The origin-country of 26 studies (%37.7) was in the UK, six studies (%8.7) in the USA, three studies (%4.3) in Iran, and two studies (%2.9) in Australia, Canada, China, Greece, Saudi Arabia, Norway, Brazil, Mexico, New Zealand, India. Other studies were performed in Belgium, Indonesia, Jordan, Mozambique, the Republic of Ireland, South Africa, Sweden, Slovenia, Thailand, Poland, Portugal, Nigeria, Netherland, Denmark. (Figure.4)
These studies have been published in 55 different journals. Seven articles (%10.1) in the "Journal of the Operational Research Society" and three articles (%4.3) in the Journal of Advanced Nursing", "Health Systems" and two articles (%2.9) have been published in any of journals "Health Informatics Journal", "Health Policy", "Nurse Education Today", "Systems Research and Behavioral Science".

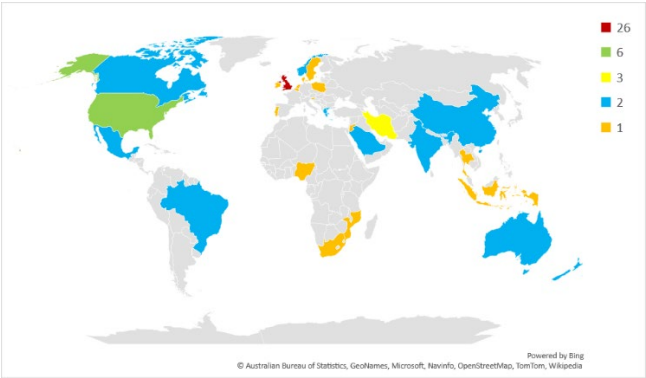

Figure 4: Geographical distribution of using soft operations research methods in healthcare problems

The research subjects in the reviewed studies were classified into four categories: Healthcare Management, Health Informatics, E-Health, and Medical Education.
A total of 44 studies (%63.8) were included in the healthcare management category, 13 studies (%18.9) in health informatics category, nine studies (%13) in e-health category, and three studies (%4.3) in medical education category. (Figure.5)
The information extracted from the studies based on the healthcare fields and methods used in the four categories is shown in Tables 1-4.

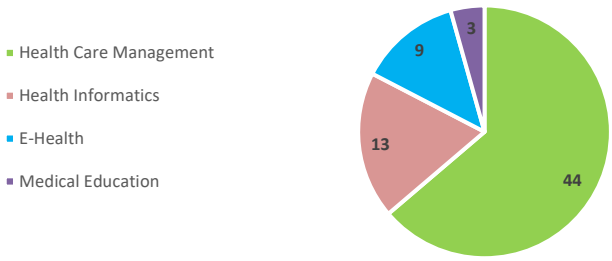

Figure 5: Frequency of Used Soft Operations Research Methods in Healthcare Categories

Table 1. Soft Operations Research Methods in Healthcare Management Category

Healthcare Management	Fields								Methods		
	Requirement Identification	Problem Solving	System Design / Implementation	Process Improvement	Policy Making	Knowledge Management	Managing Resilience	Marketing	SSM	ISM	CM
El-Taliawi, et al. (2021) (21)					*				*		
Pilevari, et al. (2021) (22)	*						*		*	*	
Sarmiento, et al. (2020) (23)	*					*					*
Lamé, et al. (2020) (24)				*					*		
Lopes, et al. (2020) (25)					*				*		
Abrantes, et al. (2020) (26)	*										*
Khayame, et al. (2020) (27)					*				*		
Martin, et al. (2020) (28)	*								*		
Rees, et al. (2018) (29)			*								*
Emes, et al. (2017) (30)				*					*		
Newell, et al. (2017) (31)		*							*		
Kumar, et al. (2015) (32)	*									*	
Pessôa, et al. (2015) (33)		*									*
Talib, etal. (2015) (34)	*									*	
Kotiadis, et al. (2014) (35)	*		*						*		
Sinclair, et al. (2014) (36)	*								*		
Pentland, et al. (2014) (37)						*			*		
Thomas, et al. (2014) (38)	*								*		
Vandenbroeck, et al. (2014) (39)					*				*		
Duryan, et al. (2014) (40)				*							*
Price, et al. (2013) (41)	*								*		
Holm, et al. (2013) (42)	*								*		
Kotiadis, et al. (2013) (43)	*								*		
Heyrani, et al. (2012) (44)			*						*		
Hodges, et al. (2012) (45)			*						*		
Dalkin, et al. (2012) (46)				*					*		
Holm, et al. (2011) (47)		*		*					*		
Carr, et al. (2009) (48)	*		*						*		
Mukotekwa, et al. (2007) (49)				*					*		
Sachdeva, et al. (2007) (50)	*			*							*
Kotiadis (2007) (51)	*								*		
Reed, et al. (2007) (52)	*								*		
Kalim, et al. (2006) (53)	*								*		
Kotiadis, et al. (2006) (54)	*	*							*		
Wells (2006) (55)	*								*		
Fahey, et al. (2004) (56)	*	*							*		
Luckett, et al. (2003) (57)			*						*		
O'Meara (2003) (58)	*								*		
Adamides, et al. (2001) (59)	*	*							*		
Clarke, et al. (2001) (60)	*			*					*		
Lehaney, et al. (1999) (61)	*								*		
Lehaney, et al. (1996) (62)	*								*		
Wells (1995) (63)		*							*		
Lehaney, et al. (1994) (64)	*								*		

Table 2. Soft Operations Research Methods in Health Informatics Category

Health Informatics	Fields								Methods		
	Requirement Identification	Problem Solving	System Design / Implementation	Process Improvement	Policy Making	Knowledge Management	Managing Resilience	Marketing	SSM	ISM	CM
Akinnuwesi, et al. (2020) (65)	*		*								*
Sharma, et al. (2019) (66)		*	*						*		
Sandiwarno (2018) (67)			*						*		
Salmeron, et al. (2017) (68)	*										*
de Kruijff (2017) (69)	*		*						*		
Milioni (2016) (70)	*	*							*		
Kononowicz, et al. (2014) (71)	*		*						*		

Health Informatics	Fields								Methods		
	Requirement Identification	Problem Solving	System Design / Implementation	Process Improvement	Policy Making	Knowledge Management	Managing Resilience	Marketing	SSM	ISM	CM
Leonhardt, (2014) (72)	*										*
Unertl, et al. (2009) (73)	*		*						*		
Allaf (2009) (74)	*	*							*		
Roy, et al. (2006) (75)	*								*		
Allam, et al. (2004) (76)	*								*		
Macias, et al. (1995) (77)		*							*		

Table 3. Soft Operations Research Methods in E-Health Category

E-Health	Fields								Methods		
	Requirement Identification	Problem Solving	System Design / Implementation	Process Improvement	Policy Making	Knowledge Management	Managing Resilience	Marketing	SSM	ISM	CM
Poleto, et al. (2021) (78)	*										*
Carter, et al. (2019) (79)	*								*		
Rahimi (2018) (80)	*										*
Prybutok, et al. (2017) (81)	*							*	*		
Szwed, et al. (2014) (82)	*										*
Guo, et al. (2013) (83)		*							*		
Al-Kadi (2012) (84)			*						*		
Raghupathi, et al. (2009) (85)	*		*						*		
Jones (2009) (86)	*		*						*		

Table 4. Soft Operations Research Methods in Medical Education Category

Medical Education	Fields								Methods		
	Requirement Identification	Problem Solving	System Design / Implementation	Process Improvement	Policy Making	Knowledge Management	Managing Resilience	Marketing	SSM	ISM	CM
Železnik, et al. (2017) (87)	*								*		
Por (2008) (88)	*								*		
Stokes, et al. (2004) (89)	*								*		

5. Discussion

Soft operations research methods by problem structuring approach and using stakeholders' views were used in a wide range of healthcare fields. This section examines the application of soft operations research methods in each of the four categories: healthcare management, health informatics, e-health, and medical education.

5.1. Healthcare management category

Healthcare management is a field that includes leadership and direction to healthcare organizations. Health care organizations often meet a variety of problems and complexities that these problems exist in costs control, quality of patient care delivery, patient flow management, personnel management, process redesign and the addition of new departments (Kahraman C & Topcu YI,2018).In this category, studies have been performed using SSM, ISM, and CM methods in Requirement Identification, Problem Solving, System Design and Implementation, Process Improvement, Policy Making, Knowledge Management, and Managing Resilience fields.

Soft operations research methods have been used in various aims of healthcare management. In the requirement identification field, used SSM, ISM, and CM methods to drawing system boundaries, identifying system activities and requirements with stakeholder views, and developing a comprehensive framework in order to identify and classify critical dimensions for healthcare systems. (Pilevari N & Shiva MV,2021; Sarmiento I et al.2020; Abrantes JA et al.,2020; Martin AC& O'Meara P,2020; Kumar D,2015; Talib F& Rahman Z,2015; Sinclair E et al.,2014; Thomas LH et al.,2014; Price M et al.,2013; Kotiadis K et al.,2013; Carr SM et al.,2009; Sachdeva R et al.,2007; Fahey D et al.,2004; O'Meara P,2003; Lehaney B & Paul RJ,1995; Lehaney B & Paul RJ,1994)
In the Problem-Solving field, SSM and CM methods have been used to better understand the problems and provide solutions (Newell K et al., 2017; Pessôa LAM et al., 2015; Holm LB & Dahl FA, 2011; Kotiadis K & Mingers J, 2006; Fahey D et al.,2004; Adamides E & Maniatis A,2001; Wells J,1995). In the field of System Design and Implementation, SSM and CM methods have been applied to understanding complexity and identifying problems and barriers to the design and implementation of healthcare systems (Rees D & Y. Cavana R, 2019; Kotiadis Ket al., 2014; Heyrani A et al.,2012; Hodges S et al.,2012; Carr SM et al., 2009; Luckett. S & Grossenbacher K,2003).
In the Process Improvement field, have been used SSM and CM methods for designing and improving organizational processes and patient care pathways (Lamé G et ak.,2020, Emes M et al.,2017; Duryan M et al.,2014; Dalkin SM et al.,2012;Holm LB & Dahl FA, 2011; Mukotekwa C& Carson E,2007; Sachdeva R & Williams T,2007; Clarke CL &Wilcockson J,2007) and in the field of Policy Making, SSM method has been applied to developing health policies on the provision of healthcare services (El-Taliawi OG & Hartley K,2021; Lopes E et al.,2020; Khayame HA& Abdeljawad MM,2020; Vandenbroeck P et al.,2014).In the field of Knowledge Management have been used SSM and CM methods for improving the design and implementation of knowledge management by enabling integration in knowledge acquisition and management in healthcare (Sarmiento I et al.,2020;Pentland D et aal.,2014) and in the Managing Resilience field, SSM and ISM methods have been applied to identifying the factors affecting the resilience of healthcare systems (Pilevari N& Shiva MV,2021).
Generally, making changes in processes and structures in health care organizations due to the complexity and multiplicity of stakeholders' views are always faced with resistance from patients and medical staff, and create problems in this area.Therefore, identifying their views and needs is very important for health care managers, and making changes will not be successful if they do not pay attention to the stakeholders. The findings of the health care management category also show that the most used soft operations research methods have been in identifying the views and needs of stakeholders.
Also, identification of requirements using soft operations research methods in combination with simulation techniques has also been used to improve the process, which has yielded acceptable results.
The application of soft operations research methods in health care management can be effective in the fields of process improvement, improving patient flow, redesigning medical centers and identifying their problems.

5.2. Health Informatics Category:

Health informatics is a field that uses information technology to organize and analyze patient health records to improve healthcare outcomes and collaboration between diverse healthcare providers.
In this category, studies have been carried out using the SSM and CM methods in Requirement Identification, Problem Solving, and System Design and Implementation fields.
In the field of Requirement Identification, SSM and CM methods have been applied to identifying factors affecting the success of health information systems (Akinnuwesi BA et al.,2020; Salmeron JL et al.,2017; Allam O et al.,2004). In the Problem Solving field, has been using the SSM method to identify barriers, problems and providing solutions to health information systems (Sharma R et al.,2019; Milioni K,2016; Allaf MS,2009; Macias-Chapula CA,1995), and in the field of System Design and Implementation, SSM and CM methods have been applied to designing models and implementation of information systems in healthcare (Akinnuwesi BA et al.,2020; Sandiwarno S,2017;de Kruijff A,2017; Kononowicz AAet al.,2014; Unertl KMet al.,2009).
The use of soft systems methodology in identifying requirements and system design and implementation has been the most application of soft operations research methods in health informatics. The first step in designing health information systems is to identify the system requirements. User - centered design increases the success rate of system implementation. Given the importance of user involvement in system design, these methods can play an important role in the primary phases of design. Soft operations research methods can be used to identify system requirements, identify system problems, identify factors affecting unsuccessful implementation of system and design health information systems.

5.3. E-Health category

E-Health is the use of information and communication technologies (ICTs) to optimize the delivery and receipt of health information and services. In this category, studies have been conducted using SSM and CM methods in Requirement Identification, Problem Solving, System Design and Implementation, and Marketing fields.In the field of Requirement Identification, SSM and CM have been used to identify variables that can be impacted Successful performance in the e-health system (Poleto T et al.,2021; Szwed P & Skrzyński P,2013; Raghupathi W&Umar A, 2009; Jones K,2009). In the Problem Solving field, the SSM method has been applied to understanding problems and malfunction and developing strategies in e-health systems (Guo Xetal.,2013). In the field of

System Design and Implementation, has been using the SSM method to design and evaluate e-health systems (Al-Kadi K ,2012; Jones K,2009)and in the Marketing field, has been using the SSM method to improve e-health marketing (Prybutok Get al.,2017).In the e-health category, the most common use of soft operations research methods has been SSM in identifying requirements. The adoption of e-health and telehealth systems is always met with resistance due to changes in the patient care pathways or the routine processes of health care organizations. The importance of the user's role in adopting these systems is undeniable, and the design and implementation of these systems for achieving sustainability and development on a larger scale should be based on the user requirements and views. Soft operations research methods can be used to identify requirements in the design of e-health and telehealth systems and user-centered design of these systems, as well as to identify reasons for non-adoption and sustainability problems of these systems.

5.4. Medical education category

Medical education, like other categories in this study, due to social interactions, needs to understand the requirements and views of educators, learners and other stakeholders. The purpose of used soft operations research methods in the field of medical education in the reviewed studies is to identify the educational requirements of nurses in the future and evaluate new methods of nursing education (Železnik D et al.,2017; Stokes PJ, Lewin D,2004). In medical education category, all three studies have been conducted to identify the requirements by SSM method. Soft operations research methods in the field of medical education can be used to identify educational requirements, improve the quality of education and investigate the problems in the medical education system.

6. Conclusion

Soft operations research methods have been used for various purposes in different areas of the healthcare system over the past years. The geographical distribution of the use of these methods shows that it is the most widely used in the United Kingdom, which is the originator of this method. In most of the reviewed articles, the soft operations research method for problem structuring was the soft systems methodology. SSM is applicable for a wide range of problem situations in several areas of healthcare settings.

Today, the problems in the field of healthcare are widespread, and e-Health is portrayed as a solution that can resolve many current problems with healthcare. These include the rising costs of treating aging populations and chronic diseases, inaccurate records and treatment due to human error, and fragmented healthcare delivery.

E-Health is the use of information and communication technologies to enable and improve health and healthcare services. E-Health refers to a growing variety of platforms, from complex national programs to telehealth and mobile health applications.

While the use of information communication technology in healthcare undeniably has benefits, attempts to implement these programs have led to significant problems. Rather than solving the issues they sought to address, cyclically, these e-Health implementations often become wicked problems.

Now, due to the importance of successful implementation of e-health and telehealth systems, the purpose of this systematic review was to portray the ability of soft operations research methods to solve wicked problems in various fields of health and especially e-health and telehealth.

Despite the many capabilities of soft operations research methods in identifying and understanding the needs of users and stakeholders in the user-centered design of e-health and telehealth systems, little attention has been paid to these methods.

This small number of studies conducted by soft operations research methods that also reported acceptable results could be the beginning of using these methods for the adoption and development of e-health and telehealth systems.

So soft operations research methods can be used for future studies. These methods will help future e-health and telehealth design and implementation projects, in identifying what might be the critical factors in success and failure.

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