The Role of Data in Crisis Management Models in the Health Care Context

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Abstract: Successful crisis management is consisted of different factors, varying actors and operation environments. Health care system is one of the most critical sectors in societies to operate also in a crisis situation. In the middle of a crisis, digitalization and access to data can have an important role as an enabler. In this paper, the role of data in crisis management models in health care context is studied. The theoretical frame is derived from the crisis management literature review. The study is able to identify the role of data in seven critical elements in crisis management models that need consideration during crisis, namely data has supporting, enabling as well as critical role in technology, strategy, government, adaptation mechanisms, scenarios, security of supply chain and co-operation in crisis management. As a result of the study, different aspects of data in promoting successful crisis management are proposed.

1 INTRODUCTION

There are different kind of crises such as economic, war, natural disaster, health, technological and human-made crisis to mention just a few. Crises can be described through three elements: depth, duration and resilience (Maritsa and Kalemis, 2020). We live in a constant cycle of various crises and we need to prepare, adjust, manage and learn from crises. Thus, crisis management (CM) is very much needed throughout different sectors of society. However, different CM strategies and models are needed for different crises (Khodarahmi, 2009).

In a crisis, it needs also to be considered that different stakeholders (Shallmo and Williams, 2020) have to explore several environments around them in order to build a situational picture: political, economic and social environments, technology, health and science and international relationships (Li et al., 2021). This kind of building of a situational picture requires access to relevant data.

Health care systems are one of the most critical sectors in societies being a solid foundation for daily life (Keskimäki et al., 2019). In a crisis, situations are resolved with ad hoc solutions causing complex networks of a complex of human-technology mixture (Bakos 2020). There may be signals for sudden crisis and the preparedness and resilience to shocks of health systems vary (European Observatory on Health Systems and Policies, 2020).

Previous research has acknowledged the crucial role of information technology in successful CM in the health care context. Difficulties during the management of emergencies and crisis are most often related to proper information management, as relevant and adequate data is needed promptly for the decision makers. Information technology (IT) can provide useful tools to ensure access to data, but we also need to gain a proper understanding of the real needs for information in the middle of a crisis, existing information exchange practices, and ways of communication in the stakeholders' society (Wybo and Lonka, 2003Telemedicine has enabled virtual care and emergency consultation (Hollander and Carr, 2020) although the role of telecare may still be unclear (Singh et al., 2021).

Digitalization offers opportunities in CM (Reeves et al., 2020; Gkeredakis et al., 2021); however benefits are not actualized in the crisis situations in health care context in an optimal way, e.g. too few platforms or too little data utilization is (Schofield et al., 2019) or challenges in IT integration

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or data quality and cooperation of professionals regarding the data face challenges (Hong et al., 2020). During the 2020-2021 CORONA-19 crisis, different strategies in health care were incentivized. However, there is a need for strategy as long-term planning has been identified as promoting health care digital transformation and crisis anticipation (Pérez Sust et al., 2020) and continuous anticipation to manage complexity and investments in human resources (ESPAS 2015).

IT and the available data can support health care personnel in their daily work, enable supply chain management, ensure health care financing with effeciency processes, and produce transparent processes for the governance and service delivery (Otto et al. 2015). Concerning the practical infrastructure level, transportation, power and water network, internal and external organization communication systems, and crucial supplies like oxygen, blood, medical equipments, and medication are subject to technological reliability (Zhao et al., 2019). All these functions produce fragmented data and technology platforms are one way to unify scattered data and information (Cimellaro et al, 2018).

However, data as such is not valuable but has to be transformed into understandable information that brings some value to the recipient. It has been said that "healthcare is undergoing a data revolution" (Panesar 2019). Inreasingly, real-time data analysis to create predictive modeling during the crisis has supported the mitigation of risks (Mensah et al., 2015; Lo Sardo et al., 2019). The challenges of data utilization culminate in unintegrated information management systems or non-syncretized data formulating barriers for data and information exchange between institutions (Liapiz et al. 2015). The challenges of health-care informatics were identified nearly twenty years ago (Guah, 2004) and the same stumbling blocks still exist. Beside technology solutions, the management of information is needed as well (Bose, 2003).

In this paper the aim is to study the role of data in CM. The paper describes key elements of CM models and the role of data in them in health care context and seeks answers to the following research question:

What is the role of data in successful CM in health care?

The article proceeds as follows: after this introductory section the theoretical bases of data and crisis management are presented after which the methodology part of the literature review is described. The fourth section presents the main results followed by the conclusions in the last section with suggested avenues for future research.

2 THEORETICAL BASES OF DATA AND CM

Crisis management is composed of different factors, and has been called a "multi-faceted crisis response mechanism" (Liapis et al., 2015), thus it requires multidisciplinary examination (Pearson and Clair, 1998). Crisis management models are designed and planned to prepare for a crisis and act as prespecifications or guidance of how to operate. There are examples of models that focus, e.g. information exchange (Shooley et al., 2014), effects on the economy (Estrada and Arturo, 2020), strategy (Radonjic-Simic et al. 2021), infrastructure (Mihai, 2020), technical efficiency (Ortega-Díaz et al., 2020), education (Estrada and Arturo, 2020) or signal detection, prevention and preparedness, damage limitation, recovery and learning (Pearson and Mitroff, 1993).

In general, several challenges have been identified in the literature related to the use of data and information technology. There are challenges related to poor quality of data leading to potential misinterpretations, problems with information systems, rigid processes, strict legislation and resource challenges (Vuori et al., 2019). Typically difficulties can also exist in accessing relevant information (finding the right documents or databases) due to the lack of sufficient employee training, as people do not have the skills to search for the right information (Corallo et al., 2012).

All of these challenges are also typical for health data, but there are some special characteristics that potentially hinder the usage of health data. First, health data is characterized by highly confidential personal health data leading to the challenge of securing the privacy of health data. Second, other challenges related to the use of health data are related to the heterogeneity of the data sources, interoperability between different IT systems and the fragmentation and strictness of regulatory frameworks. (OECD, 2015)

3 RESEARCH SETTING

The applied research methodology was a scoping literature review. The review was selected to provide valuable information about the topic for both

academia and business (Tranfield et al. 2003). The databases used for the literature search were Web of Science, Scopus and Ebsco. The time horizon was 2009-2021 because health care technology as well as data science developed rapidly during this decade. To get a more general picture of the literature, crisis management was considered with the concepts of health AND data; and crisis AND management AND model.

In the first phase of the literature review, a total of 633 articles were identified and furthermore, altogether 74 CM models were identified from these articles. Altogether these 74 identified CM model papers were further analysed using the Atlas content analysis program to code the content into clusters. Atlas is the qualitative data analysis and research software to analyse the content of the selected literature and cluster the themes (Atlas 2022). Altogether seven clusters were identified and the role of data in these clusters were further identified. Figure 1 illustrates these phases of the literature review and analysis.

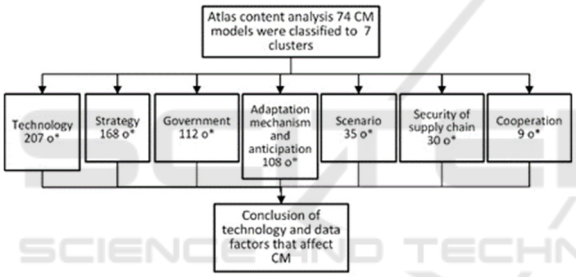

Figure 1: Illustration of the research method process (o* = occurrence of articles).

4 RESULTS

Different CM models can guide the stakeholders to co-operate with other agents and institutions (Li, e.g., 2021). A policy framework for technology and data utilization is needed, and a crisis situation may push policy development and reformulation of operational strategies (Kuščer et al., 2022) as well as data collection and communication planning (Barkbook-Johnson et al., 2017). Open-source software for data exchange and co-operation in a crisis is one way to advance situational picture formulation and problem solving (Falenski et al., 2013).

More advanced data utilization in crises enables data-aided predictive modelling and scenario analysis for environment change forecasting and pandemic crisis, for example (Danesh-Yazdi and Aiei-Ashtiani, 2019). Big data analysis is used to support multi-criteria decision-making processes in crisis management with estimation and evaluation techniques (Ersoy and Alberto, 2019; Alkahami et al., 2020) and to study the effect of crises on business management (Chen and Biswas, 2021). One critical factor is security of supply chain and resource management, and pandemic big data can navigate optimal resourcing in a crisis (Bag et al., 2021; Das et al., 2022).

Next, the key findings are listed in Table 1, showing the role of data in CM that need to be critically considered.

Table 1: Summary of the role of data in empirical findings.

Critical element	Effect factors that need to be ensured in CM	Role of data in promoting successful CM
Technology	• Remote care functionality and efficiency • Medical device usage • Sensor data, network between sensors and IT • Dashboard with real-time data • Human-robotics interaction	• Data policy • Real time data and information, minimum level of information blackouts • Big data analysis • Facilitate decision making • Human-technology, human-robotics in operation
Strategy	• Systematic data generation • Communication strategy • Education programs	• Information for providers and policy makers • Analyses how the system responds • Simulation of damage scenarios and alternative strategy testing
Government	• Guidance means for data and technology utilization in services	• IT and data policy • Produce data and information for decision makers to prepare legislative enablers • Health and rescue clinical governance
Adaptation mechanisms	• Health IT acceptance • Platform for health and government actors • Virtual interaction • Education	• Transparent information on technology implementation processes • Health care professional education provides civic resilience

Table 1: Summary of the role of data in empirical findings (cont.).

Critical element	Effect factors that need to be ensured in CM	Role of data in promoting successful CM
Scenarios	• Prevention and recovery • Simulation (live, agent based computer, virtual reality) • Systematic databased evaluation for the situational picture • Machine learning in scenario development	• Tools for data analysis and KM tools for evaluation • Data mining techniques • CM information literacy • Situational picture formation
Supply chain	• Integration of different technologies (e.g., transportation • Goods and service delivery • Resource and inventory management	• Multimodal communication technology that enables risk management and decision making • Health and clinical management • Absorbing best solutions and practices from other industries • Identification new problems • Network management
Co-operation	• Collaboration processes among health care industry stakeholders • Strategy, operation, and innovations for prevention of crisis effects	• Shared knowledge and other resources • National and global knowledge sharing between professionals • Complexity control • E-learning.

Nutley et al.'s (2014) decision making model for health data context addresses "behavioral, technical, and organizational constraints to data use" to support decision making. These data related factors proposed by Nutley et al. (2014) were also present in the CM models analysed in this paper. For example, the data infrastructure factor revealed that technology is already smart, but technology utilization may be challenging. There are many technological systems, solutions and applications with several measuring and controlling means (e.g., sensors, internet of things IoT, wireless technology) in health care. However, connecting the different IT systems e.g. between different hospitals, rescue services or transportation is not an easy task. Integration of the IT systems internally in a hospital is challenging e.g. because the challenge of data interoperability. Even a simple digital application utilization requires a health care ecosystem around it: the manufacturer of the platform, the equipment service or device provider, and furthermore, an ecosystem for the communications, e.g., the telecommunications infrastructure provider and the institution (Jeong and Shin, 2016). However, when integration is successful, the literature results show that communication can be strengthened and real time data made possible, e.g., by sensors and IoT (ibid.); but successful communication either via technology or humans requires strong cooperation (Sentell et al., 2019). Technology utilization and the benefits obtained from the technology solution need to be "sold" to the actors to be implemented. It is important to identify how the benefits occur in practice, at the different levels, e.g., at state level, corporation, profession or family and individual level (Oborn et al., 2021).

Furthermore, the factor of data availability faces similar challenge to infrastructure, i.e., how to obtain integrated data. Different solutions produce data, but it is another matter whether the actors have access to the data or whether the data is usable (Lenert, 2012). The literature covers information management in data availability in more general terms than just in a crisis context, often in the knowledge management (KM) context (Alhuwail, 2021; Thye et al., 2020.) Although the data sources can provide valuable information for the actors in the crisis (Shooley et al., 2014) what kind of means and possibilities there are for data exchange between institutions. Access to a certain data source (e.g. geographic information) is possible in one industry while surprisingly, in another industry (health care sector) access is rejected.

From this we reach data policy factor; data availability and data policy should go hand in hand to secure appropriate data and information usage as well as enabling data. Platforms, data and information usage need policy and protection methods and clear guidelines on how to utilize and document them (Tang et al., 2011; Shi, 2020). Moreover, the data quality factor raises discussion of the challenges of data or integration of other data sources. Therefore again, in a wider national and operation context, guidelines and data sharing programs and standardization for data management are needed. Data is an ever-changing resource and data development and suitable technology solutions are

essential to optimize data utilization as well as a necessary part of CM. (Alhuwail, 2021) However, data and information are useless until they are utilized. CM models can advise the actors to adopt technology solutions under pressure due to a crisis (Li et al., 2021).

5 CONCLUSIONS

The previous literature has stated that the benefits of information technology are not being actualized in health care in optimal manner even though advances e.g., in IT integration and AI and machine learning in data analysis have a lot of potential (Hong et al., 2020). The aim of this paper was to study the role of data in the CM in health care context through a literature review.

Altogether 74 different CM models were identified from the literature and clustering seven key elements: technology, strategy, government, adaptation mechanisms, scenarios, security of supply chain and co-operation. Data has an important role in every other element as an enabler in crisis operation.

In successful CM in health care, real-time information sharing between multiple actors and organizations is essential to formulate the situational picture (e.g., Ross Ashley, 2003). Furthermore, data was identified as playing a supporting role; with new or innovative technological solutions for the crisis operation and data utilization, guiding strategy modification of what needs to be done in a changing situation and how technology could be utilized. Data has also a critical role in formulating governmental actions (data policy or data production for decision makers), enabling information transparency, and providing tools for education and leadership. Most importantly, IT and modern digital solutions are needed to gather, process, and share data to enable the scenario and situational picture formulation in a crisis. One critical area to ensure is the supply chain and IT offers means of communication and network management tools to enable essential national and international co-operation in a crisis with knowledge sharing.

Governmental actions are needed (legislation, public-private data or platform sharing) to support the health care transformation to survive in crisis situations and to gain the benefits of innovative technologies, such as AI and machine learning for data analytics (Mahmood et al., 2020). Human-technology interaction is an emerging trend in crisis operations; however, it clearly needs a social approach besides technology, such as change of attitudes and education to promote competence for technology utilization (Sentell et al., 2021) as well as equality in access e.g. to virtual care services (Schofield et al., 2019). New management models and strategy development are also needed to turn a crisis into an asset (Pérez Sust et al., 2020).

Although this paper managed to give a review, it has some limitations. First, the data set was gathered from a limited search engine and does not capture the scholarly literature comprehensively. Secondly, there are many excellent examples of data utilization and technology innovations produced in a crisis operational environment that merit additional reviews in the future.

Further study of the role of data and information exchange (Vujadinovic, 2020) would be especially interesting. Cyber security was excluded from this study and, when considering digital platforms, data and medical applications, and data exchange, security issues are an important research topic. Third potential research avenue for IT and CM are simulations in crisis. Simulations offer a tool for evaluating different emergency plans and communication technologies during a crisis.

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