AN EVALUATION OF CRITICAL KNOWLEDGE AREAS FOR MANAGING THE COVID-19 PANDEMIC

Wala Abdalla, Suresh Renukappa and Subashini Suresh

Faculty of Science and Engineering,
University of Wolverhampton,
Wolverhampton WV1 1LY, UK.

Abstract

Purpose

The ability to manage the COVID-19 pandemic is contingent upon the ability to effectively manage its heterogeneous knowledge resources. Knowledge mapping represents a great opportunity to create value by bringing stakeholders together, facilitating comprehensive collaboration and facilitating broader in-depth knowledge sharing and transfer. However, identifying and analysing critical knowledge areas is one of the most important steps when creating a knowledge map. Therefore, the aim of this paper is to appraise the critical knowledge areas for managing COVID-19, and thereby enhance decision-making in tackling the consequences of the pandemic.

Design/methodology/approach

The methodological approach for this study is a critical literature review, covering publications on knowledge management, knowledge mapping and COVID-19. EBSCOhost, PubMed, Scopus, Science Direct, TRID, Web of Science and Wiley Online Library were searched for full text, peer-reviewed articles written in English that investigated on critical knowledge areas for managing the spread of COVID-19. After full screening, 21 articles met the criteria for inclusion and were analysed and reported.

Findings

The study revealed seven critical knowledge areas for managing the COVID-19 pandemic. These are: cleaning and disinfection; training, education and communication; reporting guidance and updates; testing; infection control measures, personal protective equipment; and potential COVID-19 transmission in health and other care settings. The study developed a concept knowledge map illustrating areas of critical knowledge which decision-makers need to be aware of.

Theoretical implications

The study advances the literature on knowledge management and builds a theoretical link with the management of public health emergencies. Additionally, the findings support the theoretical position that knowledge maps facilitate decision-making and help users to identify critical knowledge areas easily and effectively.

Practical implications

Providing decision-makers with access to key knowledge during the COVID-19 pandemic seems to be crucial for effective decision-making. This study has provided insights for the professionals and decision-makers identifying the critical knowledge areas for managing the COVID-19 pandemic.

Originality/value

This study fills gaps in the existing literature by providing an explicit representation of know-how for managing the COVID-19 pandemic. This paper uses an objective and qualitative approach by reviewing related publications, reports and guidelines in the analysis. The concept map illustrates the critical knowledge areas for managing the COVID-19 pandemic.

Keywords: COVID-19, coronavirus, concept map, knowledge areas, knowledge mapping.

Introduction

The novel coronavirus (SARS-CoV-2) or COVID-19 is a public health emergency of international concern that has had a large-scale global effect and has compelled people to significantly alter their lifestyles (Zhou *et al.*, 2020a; Khowaja *et al.*, 2021). As of 15th November 2021, COVID-19 had been transmitted to 253,163,330 people resulting in 5,098,174 verified deaths (WHO, 2021). In addition, the pandemic has seriously affected economic and social development (Zhou *et al.*, 2020a). Over 23 months into the pandemic, it remains a global challenge to identify the presence and spread of the virus.

The World Health Organization (WHO) recommended that governments worldwide should quickly intensify active surveillance to identify infected individuals to allow rapid isolation and quarantine (Kummitha, 2020). Meanwhile, Weintraub *et al.* (2021) noted that public health leaders are recommending a combination of nonpharmaceutical interventions in an attempt to slow the transmission of the novel coronavirus. However, this alone will not end the transmission of COVID-19. Therefore, a safe and effective vaccine is a critical component in reducing COVID-19-related illnesses, hospitalisations and deaths and in restoring the global economy (Khowaja *et al.*, 2021; Weintraub *et al.*, 2021). Scientists around the globe are trying to develop novel vaccines and effective therapies to reduce the spread of COVID-19 (Mortazavi *et al.*, 2021). To address these challenges, knowledge is increasingly being accessed and shared across different countries, organisations, functional departments, and among professionals. However, this knowledge interdependence creates new management challenges resulting from the risks and difficulties of knowledge transactions across boundaries. Providing decision makers with access to key tacit and explicit knowledge during the COVID-19 pandemic seems to be critical for effective decision-making.

On the other hand, smart technologies and big data analytics have played an important role in identifying transmission of the virus and in offering insights into the data necessary for prevention and control measures (Kummitha, 2020; Zhou *et al.*, 2020a). Agbehadji *et al.* (2021) noted the significant contributions of adopting artificial intelligence (AI) and big data analytics in facilitating contact tracing. For example, by creating an epidemic intelligence dashboard through data analytics and a visualisation tool, relevant data can be easily located, accessed and converted into business intelligence that is ready for sharing among healthcare professionals in real-time. This can help healthcare professionals to improve their understanding of the crisis, create powerful leverage in terms of policy/strategic interventions, and allow informed decisions to be made to cope with the pandemic. Additionally, Shi *et al.* (2021) noted the emergence of AI-based technologies for medical image acquisition and analysis of COVID-19 cases. This will help to automate scanning and detection procedures, especially in the area of reducing contact between patients and frontline hospital workers. Gombos *et al.* (2021) observed that, in times of epidemics, it is essential to translate scientific findings into digestible information for government policy makers who have only a short time in which to make critical decisions. Wiig (1997) argued that knowledge will be the key to success in the twenty-first century, due to the fact that it generates a value for organisations

when it is employed. Therefore, the availability of data, information and knowledge is very important in managing the COVID-19 pandemic.

Considering the characteristics of strong infectivity, a long incubation period and uncertain detection of COVID-19 (Zhou *et al.*, 2020a), combined with the constraints of logistics, mutations and vaccine acceptance (Khowaja *et al.*, 2021), there is a dire need for scientific and technological support in the global pandemic response, not only to control and prevent the spread of the virus, but also to provide recommendations regarding safety guidelines and hygiene, to improve people's immune system functioning and also to help improve the circumstances in which people are living during the pandemic (Khowaja *et al.*, 2021; Zhou *et al.*, 2020a). One way to accomplish the aforementioned task is to manage COVID-19-related knowledge. Hence, the ability to manage COVID-19 is contingent upon the ability to manage the related knowledge resources effectively. Jallow *et al.* (2020) recommended in their study that, to address the effects of COVID-19, knowledge should increasingly be accessed and shared across sectors and national boundaries. Therefore, there is a need for cross-sector collaboration to capture and share best and worst practices related to managing COVID-19 and the concomitant issues.

Market complexity as well as internal organisational trends and developments have changed the ways in which firms organise their activities, locally as well as globally, both in terms of tangible and intangible assets (Michailova and Nielsen, 2006; Drucker, 1993). Manesh *et al.* (2020) noted that, due to increased competitive pressure, modern organisations tend to rely on knowledge and its exploitation to sustain a long-term advantage. The challenge of managing knowledge is a daunting task for any organisation. An organisation's knowledge resources are complex and multifaceted, ranging from tacit components to knowledge that is explicitly represented and understood.

Present and future societies are based on knowledge (Drucker, 1988). Chaudhuri *et al.* (2020) stated that in this knowledge era, the key determinant for the sustainability and growth of any organisation, sector or country is based on their ability to manage their knowledge resources. Likewise, Ferreira *et al.* (2018) noted that the current knowledge economy requires companies to create new business structures and new concepts for the management of their resources to remain competitive. Knowledge has been and continues to be the key to success and competitive advantage for all organisations (Ramona and Alexandra, 2019). Michailova and Nielsen (2006) noted that assertions about the importance of knowledge, and especially tacit knowledge, for constituting competitive advantage, organisational performance and organisational success have been put forward by, among others, Nonaka and Takeuchi (1995), and Grant (1996). Additionally, Carayannis *et al.* (2017) noted that there is increasing interest in adopting systems to help organisations retain and transfer knowledge while, at the same time, creating value. This process involves ensuring that the right user has the right knowledge and uses this knowledge to improve organisational performance (Jennex *et al.*, 2009; Kruesi *et al.*, 2020).

Such systems rely on a precise understanding of Knowledge Management (KM) processes and, specifically, an understanding of how knowledge is created, shared/transferred, acquired, stored/retrieved, and applied throughout an organisational system. Suresh and Egbu (2008) noted that KM consists of distinct but interrelated processes that are not linear but can be iterative. The authors noted that KM can be defined as "a process by which knowledge is identified, captured, codified, stored, disseminated (shared/ transferred), implemented (adapted, transformed, synthesised) and its impact measured for the benefit of an organisation".

For professionals dealing with the COVID-19 pandemic, it can prove difficult to access core knowledge for highly knowledge-intensive activities, such as public health problem-solving, decision-making, etc. This situation calls for knowledge mapping to increase the visibility of knowledge sources to facilitate and accelerate the process of locating relevant expertise or experience. It is now widely accepted that the challenge of KM is to understand how to create practical solutions to support individuals, groups and organisations as they generate and capture multi-faceted knowledge so as to suit the particular requirements of the context of their application (Despres and Chauvel, 2000). As Skyrme and Amindon (1997) have noted, KM has been most commonly researched within organisations, and knowledge mapping remains an emergent research area.

Increasing attention has been paid to knowledge maps as an important subfield of KM; they are recognised as playing an imperative role (Balaid *et al.*, 2016). Knowledge mapping is a novel analysis tool that combines theories and methods from mathematics, graphics and other disciplines to reveal the core structure, developmental history, hotspots and integral knowledge architecture of a discipline (Liang *et al.*, 2018). Renukappa and Egbu (2007) remarked that knowledge mapping is a field within KM that aims to optimise the efficient and effective use of an organisation's sustainability-related knowledge. Hence, a knowledge map will effectively foster, capture, generate, transfer, codify, store and utilise knowledge (Balaid *et al.*, 2016; APQC, 2018b). Mapping COVID-19-related knowledge allows knowledge resources, ideas and links to be represented visually; thus, it aids stakeholders in identifying and locating what knowledge is critical, where it resides and how it flows (APQC, 2018b).

However, despite the evident need to map knowledge related to COVID-19, and the significant benefits and implications for controlling the spread of the virus and enhancing decision-making, the current literature indicates that there is an exclusive focus on the use of technology to apply restrictions and lockdown strategies, while ignoring one of the most critical elements for tackling the spread of the virus and informing and enhancing decision-making – the need to identify and map knowledge related to the COVID-19 pandemic. There are no published studies appraising the critical knowledge areas for managing the spread of COVID-19 and for enhancing decision-making to tackle various facets of the pandemic. Therefore, this study aims to fill this gap.

The aim of this study is the appraisal of critical knowledge areas for managing COVID-19, and for enhancing decision-making to tackle the wide-ranging facets of the pandemic. Henceforth, the research question addressed is: “what are the critical knowledge areas for enhancing decision-making during the COVID-19 pandemic?”. This study, thus, opens up a discussion about the new paradigm of emergent knowledge mapping strategies for public health emergencies. This study provides practical insights for professionals and decision-makers in helping them to identify the critical knowledge areas for addressing the COVID-19 pandemic.

This study involved a review of the literature to explore the critical knowledge areas for managing the COVID-19 pandemic and for facilitating decision-making in addressing its consequences. The study revealed seven critical knowledge areas for managing the COVID-19 pandemic. They are: cleaning and disinfection; training, education and communication; reporting guidance and updates; testing; infection control measures, personal protective equipment; and potential COVID-19 transmission in health and other care settings. The study proposed a concept knowledge map illustrating these critical knowledge areas. This work makes a major contribution to research on KM and the management of public health

emergencies by demonstrating how knowledge mapping, as one of the most powerful KM approaches, can enhance quick and effective decision-making.

The structure of the paper is as follows. It begins by presenting the theoretical background of KM and knowledge mapping, followed by a literature review of KM and knowledge mapping for COVID-19. Thereafter, the paper explains the research methodology adopted for this study. Analysis and discussion of the findings are then presented followed by conclusions and recommendations along with the implications for decision-makers and KM practitioners.

Theoretical background

Knowledge management

Bamel *et al.* (2021) noted that KM can be defined as an organisation's ability to "create, transfer, assemble, integrate and exploit knowledge assets". According to Gupta *et al.* (2000) KM can be defined as "a process that helps organizations find, select, organize, disseminate, and transfer important information and expertise necessary for activities such as problem-solving, dynamic learning, strategic planning, and decision-making". There is no single definition of KM as it has been conceptualised in a variety of ways; for example, it can be regarded as a management process, organisational ability or, as more recently, as a type of dynamic capability (Bamel and Bamel, 2018; Obeso *et al.*, 2020; Bamel *et al.*, 2021). However, the current literature on KM indicates that effective KM is related to the processes and infrastructures organisations use for knowledge acquisition, creation, generation, storage, sharing, dissemination and utilisation for formulating strategy, making strategic decisions and performance (Wang and Wu, 2020; Caputo *et al.*, 2019; Ferreira *et al.*, 2018; Malik *et al.*, 2020; Zack, 2002) and that it is used to gain and sustain a competitive advantage (Davenport and Prusak, 1998; Ferreira *et al.*, 2016; Heisig *et al.*, 2016). In general, KM is considered to be a process that enables a firm "to leverage knowledge to enhance competitiveness" (Heisig *et al.*, 2016).

A knowledge-based view of the firm states that these resources and capabilities are both knowledge-related and knowledge-intensive (Grant, 1996; Ferreira *et al.*, 2018). According to Bamel *et al.* (2021), a knowledge-based view of a firm posits that firm-possessed knowledge is usually socially complex and difficult to imitate, thus leading to sustainable competitive advantage (Alavi and Leidner, 2001). According to Carayannis *et al.* (2017), effective KM requires functionality in three basic and essential organisational processes: the generation, dissemination and application of knowledge. In order to achieve this, organisations must maintain learning loops in all organisational processes; systematically disseminate new and existing knowledge throughout an organisation; and apply knowledge wherever it can be used in an organisation. Furthermore, the amount of information, knowledge, skills and other resources that companies can access and use has been identified as one of the key aspects of value co-creation (Caputo *et al.*, 2019). Therefore, firm innovativeness and competitiveness may improve when alliances are established with partners who have strong capabilities and broad social capital, allowing them to create value, growth, technological knowledge and legitimacy through new knowledge resources (Vasudeva *et al.*, 2013; Carayannis *et al.*, 2017). Accordingly, Bamel *et al.* (2021) highlighted the importance of entering strategic alliances as a vital resource for the creation or acquisition of firm-specific knowledge. Through strategic alliances, firms can access to new knowledge, learn new things and thus, enhance their strategic position in a competitive landscape (Das and Kumar, 2007; Bamel *et al.*, 2021).

Papa *et al.* (2020) noted that innovating as well as transforming knowledge into economic value is the key to economic growth and competitive success in every business context. In this regard, a key aspect of the process of knowledge creation and innovation is the ability of the organisation to absorb external knowledge – absorptive capacity. This has emerged as a concept that connects across the literature on dynamic capabilities and organisational learning (Caputo *et al.*, 2019). Papa *et al.* (2020) also noted that external knowledge sourcing is perceived not only as a key driver of business innovation performance but also as a crucial driver of growth for a technology-driven intelligent environment. According to Scuotto *et al.* (2017), absorptive capacity can be defined as an enterprise's ability to acquire external knowledge, combine and assimilate it within the organisational setting. Thus, it refers to an organisation's ability to convert external knowledge into innovation (Scuotto *et al.*, 2017). Similarly, Mehreen *et al.* (2021) defined absorptive capacity as the ability of organisations, and the individuals within them, to understand and apply the information they receive. Additionally, Santoro *et al.* (2020) defined absorptive capacity as the ability to scan the external environment and to integrate new external knowledge into innovation processes. Singh *et al.* (2020) noted that absorptive capacity conveys an organisation's ability to advance its understanding, valuation, absorption and application of external knowledge by integrating particular activities to achieve competitive advantage and superior performance.

Scuotto *et al.* (2017) asserted that enterprises need to intensify their capacity to absorb external knowledge, mainly from the virtual environment, and combine it with internal knowledge. The authors further noted that absorptive capacity enables enterprises to convert external knowledge into new technological knowledge, thereby improving the knowledge capacity of enterprises and their innovation performance. Santoro *et al.* (2020) noted that absorptive capacity advances the ability of organisations to mix external knowledge with internal technical resources, and thus enhances their competitiveness. Singh *et al.* (2020) suggested that absorptive capacity represents a bridge between the external environmental factors affecting a firm and innovation-related activities which create value for enhanced performance. Thus, absorptive capacity enables firms to increase their stockpile of knowledge and to exploit external knowledge, and these capacities, in turn, improve innovation performance (Santoro *et al.*, 2020). However, Singh *et al.* (2020) also noted that absorptive capacity is not simply developed in order to enhance a firm's innovation capability. Absorptive capacity enables the firm to adjust and develop its abilities by reconfiguring strategic resources to achieve present and future needs and enact appropriate responses to changes in the business environment.

The literature identified two categories of absorptive capacity (Cohen and Levinthal 1990; Lane and Lubatkin 1998; Scuotto *et al.*, 2017): potential absorptive capacity and realised absorptive capacity. Potential absorptive capacity is characterised by knowledge acquisition and assimilation. Realised absorptive capacity is distinguished instead by knowledge transformation and exploitation. Moreover, Mehreen *et al.* (2021) noted various (internal and external) barriers to absorptive capacity. These barriers include, for example, weak social integration mechanisms, conflicting source relationships and poor appropriability regimes. The authors highlighted the impact of these barriers on limiting organisations' absorptive capacity and, in turn, on enhancing their competitive advantage.

The literature on KM has long suggested that knowledge sharing enables organisations to develop competitive advantage and enhances the capacity of employees to come up with creative solutions (Monteiro *et al.*, 2008; Carayannis *et al.*, 2017; Lee *et al.*, 2021). Thus, organisations should be receptive to the development of new partnerships and adaptive to

environmental changes, especially those arising from technological evolution (Caputo *et al.*, 2019). Moreover, Iandolo *et al.* (2020) observed that, as a consequence of changing dynamics in social and business configurations, organisations which are interested in surviving over the time must develop frameworks which allow them, conceptually and operationally, to integrate smart technologies into KM processes in order to support decision-making and organisational value creation activities. For example, digital technology offers opportunities for creating experiences, processes and organisational forms that reshape organisations. Hence, it facilitates the accumulation of both internal and environmental change information, while exploiting insights that emerge as a result of the transformation of data into knowledge with strategic value. Such knowledge integrates the technology variable into the productive and business system, allowing proper cooperation and allowing advance decision-making processes to be established – especially those connected with the development of innovative processes (Castellanos and Torres, 2010; Carayannis *et al.*, 2017).

The significance of information and communication technologies (ICTs) in every organisational process and, specifically, in the development and implementation of successful KM strategies has been highlighted in the literature (Caputo *et al.*, 2019; Del Giudice *et al.*, 2014; Zammuto *et al.*, 2007; Becerra-Fernandez and Sabherwal, 2006; Malhotra, 2005). For instance, ICTs increase the speed and efficiency of information flows; this, in turn, facilitates the sharing and growth of knowledge (Kebede, 2010). Moreover, Seufert *et al.* (1999) noted that ICTs support interconnected knowledge networks but that they can, additionally, support relevant dimensions of KM processes such as storage, transfer, learning and measurement (Alavi and Leidner, 2001; Carayannis *et al.*, 2017). Consequently, Wang and Wu (2020) noted that information technology (IT) plays a crucial role in the area of KM and can serve as a facilitator, thereby helping organisations achieve their goals.

Moreover, Carayannis *et al.* (2017) argued that big data are transforming the objects of knowledge by reformulating the most important questions regarding its very creation, from research to processing, and the characteristics of reality, raising awareness of how human networks and communities are developing. Papa *et al.* (2020) observed that “big” not only refers to the sheer volume of data but also their complexity and diversity. In accordance, the literature indicates that big data and big data analytics have been used to describe data sets and analytical techniques in applications so large and complex that they require advanced and unique data (Chen *et al.*, 2012; Carayannis *et al.*, 2017; Wang, 2012; Papa *et al.*, 2020). The three most important characteristics of big data phenomena are the three “Vs”: variety, velocity and volume. Their sheer scale necessitates a complete perspective shift compared to the approach required by traditional data analysis (Carayannis *et al.*, 2017). Big data management creates or extracts knowledge from data and converts it into business advantage (McAfee and Brynjolfsson, 2012). Carayannis *et al.* (2017) observed that effective management of this knowledge leads to improved decision-making, which, in turn, increases organisational performance. Additionally, big data analytics generate improved solutions to complex organisational challenges, including the marketplace, supply chain navigation and societal and ecological performance. Therefore, organisations aiming to solve business problems and improve performance should systematically follow a process of well-defined stages to routinise the acquisition, assessment and activation of valuable knowledge from data at an accelerated rate (Chen *et al.*, 2012; Wang, 2012; Carayannis *et al.*, 2017).

Chaudhuri *et al.* (2020) noted that the ability to learn faster and adapt even more quickly provides corporations with the necessary core competence to acquire sustainable competitive advantage in a rapidly changing world order. Moreover, Singh *et al.* (2020) observed that

innovation and strategic flexibility are two of the most important ways in which an organisation can achieve a competitive advantage over rivals in dynamic markets. Therefore, within the context of managing the COVID-19 pandemic, Iandolo *et al.* (2020) noted that, in addition to focusing on traditional public health outbreak response tactics (e.g., isolation, quarantining, social distancing, and community containment), other approaches based on sophisticated computational methods must be adopted.

Wang and Wu (2020) noted that, in order to make appropriate strategic decisions, it is necessary to acquire critical knowledge rapidly; therefore, it is crucial to develop a specific set of KM procedures to deal with the COVID-19 outbreak. Kruesi *et al.* (2020) noted that the management of biomedical knowledge is key to achieving satisfactory levels of health care. In this regard, Iandolo *et al.* (2020) highlighted the importance of highlighting the role of data and knowledge sharing in times of outbreak and disaster in order to support global understanding and efficient decision-making processes (Allam and Jones 2020; Iandolo *et al.*, 2020; Wang and Wu, 2020). Additionally, Lee *et al.* (2021) noted that employees' active knowledge sharing is even more critical in a crisis as it helps to identify and solve problems quickly and effectively. Knowledge sharing is particularly important in the context of the crisis because the exchange of information, ideas and suggestions allows employees to identify or create actionable problem-solving knowledge and practice, resulting in clear orientation and guidance to deal with complex tasks and environments during the crisis (Lee *et al.*, 2021). Papa *et al.* (2020) noted that the application of smart technologies within the e-Health-care industry promotes knowledge flows among stakeholders opening up promising new threads of knowledge, which can transform the basis of technological innovation and corporate competition.

Therefore, it is necessary to build strategies to ensure open knowledge sharing among employees during a crisis such as the COVID-19 outbreak. Smart technologies assisted in containing the spread of the virus by enabling the acquisition of data from hundreds of millions of smartphones. As a result, authorities were able to increase their efficiency in terms of the use of limited medical resources. For instance, AI has been used to identify and test for the virus in high-risk subjects (Iandolo *et al.*, 2020). Moreover, Lee *et al.* (2021) noted that employees' active knowledge-sharing behaviour and knowledge maps have great potential to help organisations make quick and effective decisions and be resilient in a crisis, such as during the current COVID-19 pandemic.

Knowledge mapping

In recent years, awareness has grown about the strategic importance of knowledge within an organisation in terms of its strategic value linked to knowledge and the exploitation of knowledge (Brahami *et al.*, 2013). Originally developed for and applied in business management, knowledge mapping was proposed as a technique to foster knowledge management in organisational contexts to increased innovation and performance (Vimal and Morgans, 2020). It helps to describe what, how and where to find useful knowledge within an organisation. Knowledge can be mapped in order that it can be acquired, monitored, created, shared, and finally capitalised on and transferred (Brahami *et al.*, 2013). Thus, knowledge mapping aims to mobilise, diffuse and evaluate intellectual capital in a given organisation (Wexler, 2001). Moreover, knowledge mapping helps to identify necessary skills and information, encourages the reuse of ideas, prevents reinvention, highlights islands of expertise and emerging practices (Liebowitz *et al.*, 2000). The map can, for instance, reveal who holds

what type of knowledge, how it is stored and maintained, and what media are used to disseminate and transfer it (Burnett *et al.*, 2004; Vimal and Morgans, 2020).

Balaid *et al.* (2016) noted that there can be several objectives when utilising knowledge maps. Some organisations view it as an activity that can help them with strategic planning, while others may use it as a basis for knowledge transfer. In general, knowledge mapping deals with the problem of how best to visualise knowledge assets in order to perform specific activities, particularly when organisations that value knowledge are eager to recognise how, when and where to access it (Wexler, 2001; Balaid *et al.*, 2016).

According to Brahami *et al.* (2013) knowledge mapping is a means of (cognitive) navigation to access the strategic heritage knowledge resources of an organisation. The authors noted that there are numerous definitions of knowledge maps in the literature. Although the concept has been defined in various ways from different viewpoints, there have been no universal definitions of knowledge maps so far. While research on knowledge maps is still in its infancy, over the past few years the number of studies researching the phenomenon has continuously been increasing. There are now several streams of research central to knowledge maps, such as network analysis, information visualisation and text mining (Balaid *et al.*, 2016); however, according to Davenport and Prusak (1998), a knowledge map – whether it is an actual map, knowledge “yellow pages” or a cleverly constructed database – points to knowledge but does not contain knowledge. A knowledge map is a guide not a repository.

On the other hand, despite the inherent value of mapping organisational knowledge, certain barriers may impede the effectiveness of the technique (APQC, 2018b). For example, the American Productivity and Quality Center (APQC) (2018b) noted that one of the main barriers encountered in knowledge mapping occurs when the team doing the mapping does not understand the knowledge flow process inside the organisation. Therefore, it is important to ensure that organisations have commonly accepted and widely used validation processes in order to maintain the validity of expertise or content of the knowledge map. The so-called “knowledge is power” syndrome that exists in many organisations is another key barrier for effective knowledge mapping (APQC, 2018b). Therefore, organisations must encourage and promote a knowledge-sharing culture to win over reluctant employees who feel threatened that their own positions as employees may be compromised by sharing (Abdalla *et al.*, 2020).

Stirling and Scoones (2009) noted that governance of infectious disease risks (e.g., COVID-19) requires an understanding of often indeterminate interactions between diverse, complex, open, and dynamic human and natural systems. Furthermore, the findings of Cargnel *et al.* (2021) revealed the usefulness of knowledge mapping as a tool for visualising and identifying gaps and ultimately gaining insight into alternatives for better preparedness and responsiveness in different epidemiological scenarios. Therefore, mapping and sharing knowledge on public health emergencies, such as COVID-19, could allow key knowledge to be rapidly identified and could connect various users and stakeholders at various levels, e.g., national, regional and international levels. In this context, technical support could be provided, experiences could be shared and multilateral cooperation could be established or strengthened.

COVID-19 and knowledge management

It is considered to be one of the instruments which can help organisations adapt during times of rapid change when policies and protocols are developing quickly, and uncertainty is constantly present (Buheji and Buheid, 2020). Wang and Wu (2020) noted that, in the case of

an epidemic prevention plan, the first critical KM task is to identify what knowledge is required. Both tacit and explicit knowledge related to the COVID-19 pandemic need to be retrieved and transferred carefully. There is a significant amount of similar professional expertise that is difficult to explicate and may be labelled as tacit (Buheji and Buhaid, 2020; Wang and Wu, 2020). In fact, tacit knowledge, as defined by Polanyi (1966), is potentially more important for professionals than explicit knowledge. Tacit knowledge involves knowledge that cannot necessarily be explicated but can be employed in practical situations. It is described as “know-how” as opposed to “know-that” and constitutes an important characteristic of expertise (Polanyi, 1966).

Hossain (2020) concluded that to solve problems and global emergencies like COVID-19, it is necessary to fully understand the problem and possible solutions. This highlights the need for knowledge as a fundamental force that keeps science alive and allows scientists to thrive in their research domains supported by the best possible methods and materials to answer real-life questions. Managing COVID-19-related knowledge can help reduce the transmission of the disease and promote readiness while maintaining a safe environment (Buheji and Buhaid, 2020). Wang and Wu (2020) observed that establishing and deploying a dedicated KM platform to collect and manage the most up-to-date knowledge is essential. The authors argued that the utilisation of such platforms can enhance the accuracy, integrity and reliability of the knowledge acquired, which can mitigate panic and fear caused by misinformation and allow critical knowledge to be fully disseminated, evaluated and continuously refined when necessary. Managing COVID-19-related knowledge requires suitable organisational infrastructure which includes all technical information systems capable of collecting, storing, processing and analysing different kinds of data; this is fundamental to facilitating the flow of data in any situation (Wamba *et al.*, 2017). Buheji and Buhaid (2020) concluded that there are four sources of knowledge that come from monitoring, anticipating, responding, and learning. These sources enhance the ability of systems to succeed under varying conditions. The authors also noted that the dramatic rise of the number of people infected with COVID-19 combined with staff shortages in intensive care competencies calls for innovative solutions. This highlights the need to capture and share knowledge to help to improve the process of care at every opportunity and to reduce patient safety risks (Buheji and Buhaid, 2020).

Chellamuthu and Muthu (2020) argued that an integrated pragmatic approach under the WHO is essential in containing pandemics as international cooperation is required at various levels; these range from knowledge sharing to monetary support. Meanwhile, Nathavitharana *et al.* (2020) remarked that data characterising the extent of occupational infections in healthcare workers (HCWs) during acute and chronic epidemics are often lacking and subject to wide variability in reporting, which limits their impact. For example, HCWs in countries with high tuberculosis (TB) incidence have at least twice the risk of developing TB, compared with the general population. Although there are still major gaps in national data collection regarding the incidence of occupational TB, recent attempts by the WHO to systematically record this data have resulted in increasing prioritisation of this group as an at-risk population who may benefit from TB preventive therapy (Elavarasan and Pugazhendhi, 2020; Vaishya *et al.*, 2020). Therefore, Nathavitharana *et al.* (2020) strongly advocate for health systems to systematically record and share longitudinal data on numbers of HCWs infected with COVID-19. This transparency will facilitate urgent action to replenish and sustain resources such as personal protective equipment (PPE) and enable institutions to share and adopt successful infection prevention strategies. Examples such as the prevention of central line-associated bloodstream infections demonstrate the potential impact of national collaborative efforts to strengthen

infection prevention, although further effort is needed to optimise knowledge sharing in the context of outbreaks (Nathavitharana *et al.*, 2020).

On the other hand, Zhou *et al.* (2020c) noted the impact of the spread of low credibility information regarding COVID-19. According to the authors, along with the COVID-19 pandemic, we are also experiencing an “infodemic” of information with low credibility regarding COVID-19. Hundreds of news websites have contributed to publishing false coronavirus information. Individuals who believe false news articles (e.g., claiming that eating boiled garlic or drinking chlorine dioxide can cure or prevent coronavirus) might try ineffective or extremely dangerous actions to protect themselves from the virus (Zhou *et al.*, 2020c). Nevertheless, the more knowledge that is accumulated without proper sharing at the right time, the more difficult it becomes to communicate. Thus, Heldal *et al.* (2019) suggest that knowledge development hinges on the ability to translate between tacit and explicit knowledge (Nonaka and Takeuchi, 1995). Table 1 highlights the literature related to COVID-19 and KM which has been reviewed in this study.

Table 1: The analysis of the reviewed literature related to COVID-19 and managing knowledge

Reference	Title	Source	Country/ Territory	Methods	Discussion
Al Hakim et al. (2020)	An empirical study of knowledge mapping implementation in Indonesian organisational context.	VINE Journal of Information and Knowledge Management Systems.	Indonesia	Questionnaire/survey	Indicates that the support of technology through the use of AI, it is expected to be able to present a comprehensive, adaptive and objective knowledge mapping for the organisation.
Al-Hity et al. (2021)	Personal protective equipment guidance during a global pandemic: A statistical analysis of National perceived confidence, knowledge and educational deficits amongst UK-based doctors.	International Journal of Clinical Practice,	UK	Survey	Highlights the need for more education and for a paradigm shift towards increased use of video-streaming and virtual media to exchange knowledge and facilitate learning.
Anttiroiko (2021)	Successful government responses to the pandemic: Contextualising national and urban responses to the COVID-19 outbreak in east and west.	International Journal of E-Planning Research	Finland	Descriptive multiple case study	Discusses national and local strategies for confronting the COVID-19 pandemic. Also, sheds light on how knowledge and other societal and institutional arrangements in addition to technology deployment manifest in national responses to the pandemic.
Bhamra et al.,(2021)	Personal protective equipment: knowledge of the guidance.	British Journal of Nursing	Undefined	Survey	Concluded that unifying published PPE guidance and ensuring consistency in training can improve awareness, confidence and knowledge among nursing staff.
Buheji and Buhaid (2020)	Capturing Accumulated Knowledge and Learning of COVID-19 Pandemic from Front-Line Nurse.	Human Resource Management Research	Bahrain	Literature review	Investigates the type of nurses' COVID-19 knowledge accumulated and then suggests through a framework a way of dealing with it.
Casella (2021)	Can the COVID-19 epidemic be controlled on the basis of daily test reports?	IEEE Control Systems Letters	Italy	Letter	Examines how COVID-19 epidemics can be controlled by authorities taking decisions on public health measures on the basis of daily reports of swab test results, active cases and total cases.

Chellamuthu and Muthu (2020)	Pandemic response protocol of a non-frontline specialty in a multispecialty tertiary health care centre—a pilot model in orthopaedics.	International Orthopaedics	India	Pilot model in orthopaedics	Suggests that an integrated pragmatic approach is essential in containing pandemics as they need international cooperation at various levels, starting from knowledge sharing to monetary support.
Elavarasan and Pugazhendhi (2020)	Restructured society and environment: A review on potential technological strategies to control the COVID-19 pandemic.	Science of The Total Environment	India	Literature survey	Investigates various technology-based strategies that assist the environment in controlling the pandemic and also other viable technologies that have the potential to be used.
Holmgren et al. (2020)	Barriers to hospital electronic public health reporting and implications for the COVID-19 pandemic.	Journal of the American Medical Informatics Association	USA	Combined survey and hospital reports data	Suggests that public health agencies' inability to receive electronic data is the most prominent hospital-reported barrier to effective syndromic surveillance.
Islam et al. (2020)	Current knowledge of COVID-19 and infection prevention and control strategies in healthcare settings: A global analysis.	Infection Control & Hospital Epidemiology	Australia	Literature review	Infection prevention and control strategies should consider all the possible routes of transmission and should target all patient care activities involving risk of person-to-person transmission.
La Marca et al. (2020)	Testing for SARS-CoV-2 (COVID-19): a systematic review and clinical guide to molecular and serological in-vitro diagnostic assays.	Reproductive biomedicine online	Italy	Literature review	Highlights the importance of the different testing approaches for SARS-Cov-2 in the fight against this pandemic.
Nathavitharana et al. (2020)	Innovation and Knowledge Sharing Can Transform COVID-19 Infection Prevention Response.	Journal of hospital medicine	USA	Literature review	Focuses on the potential for innovation and knowledge sharing from an infection prevention perspective, which could enhance frontline HCW safety in the current COVID-19 pandemic.
Parra et al. (2021)	Information and communication technologies (ICT)-enabled severe moral communities and how the (Covid19) pandemic might bring new ones.	International Journal of Information Management	Norway	Analytical framework	Discusses how ICTs may enable the emergence of severe moral communities, and help to promote increasingly polarised, radicalised and even extremist viewpoints.
Rowan and Laffey (2020)	Challenges and solutions for addressing critical shortage of supply chain for personal and protective equipment (PPE) arising from Coronavirus disease (COVID19) pandemic—Case study from the Republic of Ireland.	Science of The Total Environment	Ireland	Case study	Logical first step solutions for PPE shortages would be to improve communication lines for better stock management that exploits webpage and mobile phone app development.

Swanson and Santamaria (2021)	Pandemic Supply Chain Research: A Structured Literature Review and Bibliometric Network Analysis.	Logistics	USA	A Structured Literature Review and Bibliometric Network Analysis.	Addresses, summarises and articulates supply chain management issues during pandemics by focusing primarily on the bulk of the research that has been published since the COVID-19 pandemic began.
Vaishya et al. (2020)	Artificial Intelligence (AI) applications for COVID-19 pandemic.	Diabetes & Metabolic Syndrome: Clinical Research & Reviews.	India	Literature review	Concludes that healthcare organisations are in an urgent need for decision-making technologies to handle COVID-19 and help them in getting proper suggestions in real-time to avoid its spread. AI works in a proficient way to mimic like human intelligence.
Wu et al. (2020a)	Environmental contamination by SARS-CoV-2 in a designated hospital for coronavirus disease 2019.	American journal of infection control	China	Air and surface SARS-CoV-2 RNA detection.	Investigates whether environmental contamination may play a role in SARS-CoV-2 transmission.
Yang et al. (2020)	Knowledge system analysis on emergency management of public health emergencies.	Sustainability	China	Literature review	Addresses the challenge of building a knowledge system for emergency management of public health emergencies.
Younan et al. (2020)	Challenges and recommended technologies for the industrial internet of things: A comprehensive review.	Measurement	Egypt	Comprehensive review	Suggests that enabling real-time data analysis, knowledge extraction and search techniques based on ICT (e.g., ML, AI) can reduce and control IoT and leverage its value.
Zhou et al. (2020a)	Challenges to GIS with big data.	Geography and Sustainability	China	Data-driven multi-scale mapping	Provides analysis of the spatial representation of COVID-19 material, population and social psychology at individual, group and regional levels.
Zhou et al. (2020b)	Investigating SARS-CoV-2 surface and air contamination in an acute healthcare setting during the peak of the COVID-19 pandemic in London.	Clinical Infectious Diseases.	UK	Cross-sectional observational study	Evaluates SARS-CoV-2 surface and air contamination during the COVID-19 pandemic and reveals that surface contamination was detected on a range of items.

COVID-19 and knowledge mapping

Arshad *et al.* (2021) noted that the recent COVID-19 pandemic, probably of zoonotic origin, necessitates appraisal of a multi-disciplinary “One Health” approach by coordinating human, animal and environment professionals. Community health is a complex multi-factorial process, and many components are covered under the umbrella of One Health. The One Health core competencies (collaboration, coordination, partnership, leadership, communication, ethics, systems thinking and management) have been identified as being significant in responding to pandemics or public health issues globally. Examples include the Bellagio working group, USAID/RESPOND, SMM, Rome Synthesis, and PREDICT (Frankson *et al.*, 2016; Andersen *et al.*, 2020; Zhou *et al.*, 2020a). Despite the high surge in the volume of scientific interest in pandemic response, ranging from proposals for innovative medical devices, vaccines and infection prediction to propagation models for COVID-19 (e.g., specific search and recommendation tools developed for COVID-19), systems that leverage graph-based interactive visualisations to navigate the vast research materials are not yet available (Ambavi *et al.*, 2020).

Casella (2021) noted that governments all the world over are having to make very challenging life-or-death decisions regarding the management of the COVID-19 epidemic; these involve a balance between public health and economic issues. To take such decisions, they rely on expert advice based on the results of epidemiological mathematical models and on daily case reports, based on swab test results. Furthermore, Moreira *et al.* (2019) noted that healthcare experts make several decisions every day. These can have important effects on their patients’ health and their wellbeing. Although medical care is improving, the escalating amount of data and, consequently, the way in which those data can relate to patients, are making these decisions more and more complicated (Moreira *et al.*, 2019). Therefore, sharing critical knowledge in order to manage COVID-19 is necessary to facilitate and enhance decision-making. For instance, Goniewicz *et al.* (2020) noted that national authorities should share best practices and seek a consensus on common approaches with the assistance of WHO.

Sturm *et al.* (2017) discuss how one way of addressing the needs of KM is through knowledge mapping. The authors highlighted how knowledge maps increase knowledge visibility and transparency, helping to place knowledge in a wider context and support effective communication. Moradi *et al.* (2017) noted that utilising a knowledge map greatly facilitates any individual’s or group’s decision-making process, by proposing or establishing key information which is necessary for an informed response. This process is, thus, the initial basis and one of the keys to success in the application of KM in organisations. Daña *et al.* (2020) noted that specific interaction patterns are related to increased knowledge flow, innovativeness and performance.

According to Mital *et al.* (2018), the knowledge used by decision makers is tacit knowledge, and they generally use certain mental models for evaluation when making a decision. Al Hakim *et al.* (2020) noted that knowledge mapping is an essential part of KM, stating that a knowledge map can be a bridge when implementing the KM system (KMS). A knowledge map does not contain knowledge, but, rather, it includes a conceptual picture of knowledge that demonstrates the relationships between different aspects of knowledge (knowledge profile), locations (link to the site) and knowledge owners (expert) (Kim *et al.*, 2003). Therefore, knowledge mapping represents a great opportunity to enhance skills and competencies and to improve and facilitate decision-making. Thus, it is essential to develop dynamic knowledge mapping platforms to

help to connect key stakeholders to existing explicit (codified) and tacit (practical) knowledge and facilitate knowledge exchange (Buheji and Buhaid, 2020).

Moreover, since the outbreak of COVID-19, in addition to policy documents published by governments, epidemic information has been widely disseminated through various online platforms and channels. However, as COVID-19-related data and information originates from various sources, it is unstructured, inconsistent and inaccurate (Zhou *et al.*, 2020a). Managing COVID-19-related knowledge necessitates the effective collection, storage, retrieval, mining and sharing of data (Younan *et al.*, 2020). There are huge challenges when accessing and aggregating such a vast amount of information and knowledge (Nguyen *et al.*, 2020). Hence, answering real-time queries can become extremely challenging (Younan *et al.*, 2020). Moreira *et al.* (2019) noted that, nowadays, people can use information and communication technologies to facilitate the interaction between patients and their physicians, improving the patient's quality of life. Physicians can have easy access to patients' medical records, lab results, images and information about their medication, anytime and anywhere. In the same way, patients can have access to information on their diagnostic situation as well as information about how to be as healthy as possible (Moreira *et al.*, 2019).

According to Zhou *et al.* (2020a), convenient multi-scale dynamic mapping for epidemics is one of the key challenges associated with using geographic information system (GIS) with spatiotemporal big data in order to manage the COVID-19 pandemic. The challenge when knowledge mapping is to understand how to create practical solutions to support individuals and groups as they generate or acquire this multi-faceted knowledge in a way which suits the particular requirements of their application context (Storey and Barnett, 2000; Suresh and Egbu, 2008). When done well, KM can be used as a tool to evaluate the corporate knowledge stock (e.g., knowledge of COVID-19) revealing strengths to be exploited and gaps that need to be filled (Davenport and Prusak, 1998). In order to manage the COVID-19 pandemic and control the spread of the virus, organisations need to grow the capability to share knowledge between specialised areas and across internal and external boundaries. Therefore, identifying the sets of knowledge that will make the greatest difference, where they reside and how they can be accessed and exploited for team, organisational and communal benefits is fundamental. This consideration is integral to the issue of knowledge mapping.

Wexler (2001) noted that the benefits of a knowledge map can be categorised into four groups of returns: knowledge, economic, structural and organisational/cultural. Moreover, Yasin and Egbu (2011) categorised the benefits of a knowledge map into five themes: cost saving, process improvements, knowledge improvement, value improvement and user satisfaction. However, the clearest benefit and the principal purpose of a knowledge map is to show people in an organisation where to go and who to ask when they need expertise (Wexler, 2001; Balaid *et al.*, 2016). Therefore, a knowledge map can increase transparency and reduce complexity within organisational contexts as well as preventing overlapping and repetitive activities (Wexler, 2001; Yasin and Egbu, 2011).

The American Productivity and Quality Center (APQC) (2018b) stated that the key benefits of knowledge mapping include: bringing stakeholders together to think critically about the knowledge involved in their work; highlighting the areas where critical knowledge may be at risk; enabling opportunities to create value by facilitating comprehensive collaboration and knowledge sharing; and facilitating broader in-depth knowledge transfer. Additionally, knowledge mapping techniques are relatively easy to apply, even for teams with minimal

experience. This is especially true when compared with improvement methodologies such as Six Sigma, which require significant participant training (APQC, 2018b).

Research methodology

Developing the concept map

This study sought to evaluate the critical knowledge areas for managing the COVID-19 outbreak. Knowledge mapping allows a fine-tuned understanding, by critically analysing the domains of knowledge to identify where efforts should be made in terms of capitalisation, sharing or innovation (Brahami *et al.*, 2013). The study followed the APQC (2018a) four-step guide to knowledge mapping: identify knowledge areas; draft knowledge map; evaluate risks and identify opportunities; act on the map. Using data from global infection prevention and control (IPC) guidelines compiled by organisations such as the World Health Organization (WHO), Department of Health and Social Care (DHSC), Public Health England (PHE), and the Toolkit on State Actions to Mitigate COVID-19 Prevalence in Nursing Homes, the authors identified key knowledge areas for controlling the spread of COVID-19 and combined this information with the findings from the systematic literature review reported in Table 4. This approach allowed the most important critical knowledge areas to be pinpointed.

As mentioned above, the aim of this research is to appraise critical knowledge areas in order to manage the spread of COVID-19 and to enhance decision-making to tackle the consequences of the pandemic. In order to achieve this aim, a robust methodology was adopted. The study is based on a critical analysis of the extant literature devoted to knowledge mapping and COVID-19, and discusses the potential role of knowledge mapping techniques in managing and controlling the spread of the virus and in facilitating decision-making towards recovery. Finally, the paper proposes a concept map of the areas where knowledge mapping techniques can be adopted to facilitate containment and control of the virus efforts and tackle the consequences of the pandemic. A research literature review is a “systematic, explicit, and reproducible method for identifying, evaluating, and synthesising the existing body of completed and recorded work produced by researchers, scholars, and practitioners” (Castaneda *et al.*, 2018). The critical literature review (CLR) approach entails the assessment, critique and synthesis of relevant literature regarding the topic under investigation in a manner that creates a firm foundation for advancing knowledge and facilitating new theoretical frameworks and perspectives to emerge from a wide array of different fields (Snyder, 2019). Examples of this type of review are not new in business literature (Snyder, 2019). As such, adopting a critical literature review approach is favoured in realising the goal of the paper as it allows for the inclusion of a wide range of perspectives and theoretical underpinnings from different sources (Ibn-Mohammed *et al.*, 2021).

The method used in this study followed that proposed by Tranfield *et al.* (2003), involving three stages (see Table 2): planning the review, conducting the review and reporting, and disseminating the results. The first stage involved developing a list of keywords and criteria for the inclusion of articles, as well as defining the search string to be input into the data source. Thereafter, two keywords, namely “knowledge mapping”, and “COVID-19” were identified and combined. The resulting search string was [“COVID-19” OR “Coronavirus”] AND [“knowledge mapping” OR “knowledge map”] and this was used to search the titles, abstracts and keywords of available articles. A university library search engine, with access to various databases, including Directory of Open Access Journals, Science Direct, Scopus, TRID, Web of Science and Wiley Online Library, was used to complete an online search.

Table 2: Stages of the literature review

Stage I – Planning the review	
Phase 0	Identify the need for the review
Phase 1	Prepare a review protocol
Phase 2	Develop criteria for inclusion
Stage II – Conducting the review	
Phase 3	Carrying out the review of relevant articles
Phase 4	Screening and applying inclusion criteria
Phase 5	Assess study quality
Phase 6	Extract and monitor data
Phase 7	Data synthesise
Stage III – Reporting and disseminating the results	
Phase 8	Specify dissemination strategy
Phase 9	Critically document and present the results
Phase 10	Evaluate the report

Strict inclusion criteria were used to identify appropriate studies in order to provide the best quality evidence available (see Table 3). The inclusion criteria were that articles should be full text, peer-reviewed journal articles, available online, in English and published between December 2019 and January 2021 (to ensure relevance to COVID-19); additionally, they had to have relevance to the research aim. According to Natalicchio *et al.* (2017), such choices are justified by the fact that inclusion criteria ensure the identification of the most relevant articles related to the topic under investigation. The second stage involved carrying out a review of the relevant articles. The initial search identified a total of 75 articles. These records were then screened and reduced to 42 by applying the inclusion criteria. The articles were then “eye-balled” to ensure they were consistent with the keyword search, the abstracts were assessed against the research aim, and the duplicates removed. The total number of articles was reduced to 32 as a result of this process. The full text of the selected articles was read to determine the relevance with respect to the aim of the study and the results were narrowed down to 21 articles. Finally, these 21 articles were reviewed, categorised and analysed. The third and final stage involved reporting and dissemination. This stage involved critically documenting and presenting the results from the analysis of the selected articles. A discussion of the critical knowledge areas for managing COVID-19 is outlined in the next section.

Table 3: Criteria for inclusion/ exclusion of studies

	Inclusion criteria	Exclusion criteria
Date	December 2019 - May 2021	Prior December 2019
Language	English	Papers not in English
Type	Original research papers	Articles and book reviews, dissertations
Publications	Peer-reviewed articles, government reports	Conference papers, book chapters, books, conference papers, and unpublished works.
Design	Studies follow a validated methodology	Informal papers

Focus	Studies focusing on KM, knowledge mapping and COVID-19	Studies with no relationship to the research question
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In addition, other articles and news items from the past few months of the pandemic outbreak were referenced; these were ones which focused on critical knowledge areas for managing COVID-19. A search for this information was conducted through various media platforms and outlets such as BBC News, NHS, CNN, *The Guardian*, *The New York Times*, *Business Insider*, *The Telegraph*, *The Economist*, Reuters, and *The Financial Times*. Kummitha (2020) noted that the use of media outlets to identify novel mechanisms can be useful in understanding trends and approaches adopted by various governments. The use of research articles, WHO situation reports and news from media outlets formed a basis for triangulating the data.

Table 4: Critical COVID-19 knowledge areas based on literature findings

Reference	Critical knowledge areas						
	Cleaning and disinfection	Potential COVID-19 transmission in health and other care settings	Training, education and communication	Reporting guidance & updates	Testing	Infection control measures	Improving and increasing access to PPE
Al Hakim et al. (2020)			X				
Al-Hity et al. (2021)							X
Anttiroiko (2021)		X	X				
Bhamra et al. (2021)							X
Elavarasan and Pugazhendhi (2020)				X			
Holmgren et al. (2020)				X			
Islam et al. (2020)	x					X	X
La Marca et al. (2020)					X		
Nathavitharana et al. (2020)	X	X			X		
Parra et al. (2021)	X	X					
Rowan and Laffey (2020)	X						
Swanson and Santamaria (2021)							X
Vaishya et al. (2020)				X			
Wu et al. (2020a)	X						

Yang et al. 2020	X		X			X	
Zhou et al.(2020b)	X						

Findings and discussion

The analysis of the review revealed seven critical knowledge areas that decision-makers need to be aware of in addressing COVID-19 crisis. They are reducing and minimising the risk of transmission of COVID-19; providing information about testing; improving access to PPE; enhancing infection control measures; facilitating reporting and communication; enhancing cleaning and disinfection processes. This is presented in a concept knowledge map as shown in Figure 1. Each of these critical knowledge areas is detailed below along with the know-how in Table 5. The findings indicate that knowledge mapping related to the COVID-19 pandemic has the potential to improve planning, treatment and control of the pandemic, and to enhance decision-making.

Figure 1: Map of critical knowledge to manage the COVID-19 pandemic (based on literature findings)

Table 5: COVID-19 critical knowledge areas

Know	How
Cleaning and disinfection	<p>Decontamination</p> <ul style="list-style-type: none"> • Offering decontamination systems for hospitals, nursing homes and other healthcare providers. • Distributing alcohol hand rub and COVID-19 cleaning solution to long-term care facilities when required. • Providing access to free N95 sterilisation for healthcare facilities. <p>Cleaning facilities</p> <ul style="list-style-type: none"> • Providing cleaning services for long-term care facilities. • Providing all environmental services staff with laminated daily and terminal room cleaning checklists. <p>Promote proper hand washing</p> <ul style="list-style-type: none"> • Providing resource, including poster, to promote and display proper handwashing across healthcare facilities. <p>Disinfecting nursing homes with COVID-19-positive cases</p> <ul style="list-style-type: none"> • Offering training for staff on the techniques of donning and doffing PPE as well as sanitise and disinfect nursing homes that have COVID-19-positive residents and/or employees. <p>Using UV machine for disinfection</p> <ul style="list-style-type: none"> • Uses a UV machine to disinfect face shields, N95 masks, iPads, nurse cart keys, and any other needed items. <p>Staff shower and change</p> <ul style="list-style-type: none"> • Staff shower and change at the end of shifts in designated areas at the facility before leaving unit to reduce spread of COVID-19 in the community or at homes. <p>Infection control practices</p> <ul style="list-style-type: none"> • Temperatures of staff and residents. • Isolation plans for residents coming from the hospital, dialysis, or other external sources.
Training and education & communication	<ul style="list-style-type: none"> • Conducting frequent staff education and requesting that staff only work in their facility and not others. • Continually communicating with families on pandemic activities, including testing as required. • Developing a COVID-19 resource page, updated daily with information regarding regulations, infection control, PPE and other control and prevention information • Preparing weekly member newsletters and email blasts on COVID-19-related resources and events. • Releasing the environmental steps to reduce indoor COVID-19 transmission, with recommendations and resources for facilities to follow to minimise the risk of virus transmission through indoor airflows. • Conducting virtual audits using video to verify the cleaning protocols and use of PPE in nursing homes, assisting living facilities and immediate care facilities.

	<ul style="list-style-type: none"> • Providing website updates with changes in rules and regulations, contact information, and a nurse aide programme temporary waiver for staffing. • Creating a website FAQ document for support on common questions and providing waiver guidance. • Conducting support webinars with ample Q&A time • Managing hotline and individual nursing home assistance via email • Providing support through emergency response teams available. • Providing consultation to prevent the spread of COVID-19 in nursing homes. • Creating websites with county-based data dashboard, COVID-19 frequently asked questions, jobs portal, symptom checks and state-based updates. • Using artificial intelligence (AI) with imaging, clinical symptoms, exposure history and laboratory data; create an algorithm to rapidly diagnose COVID-19 in patients • Building an online educational program for contact tracing. • Providing COVID-19 update briefing daily
Reporting/guidance/mandated reporting	<ul style="list-style-type: none"> • Reporting on updates and guidance while sharing reports through authorities and local health officials. • Mandating reporting of COVID-19 positive cases in nursing homes to strengthen protection in residential and nursing care facilities. • Sharing and collaborating reporting and enrolment instructions assistance (link and the PDF). • Providing resources for skilled nursing facilities on preventing, detecting and preparing for COVID-19. • Requiring all skilled nursing facilities to report daily updates regarding current staffing levels, the number of COVID-19 patients, capacity, supplies and equipment availability via an online survey. • Requiring all nursing homes to submit a mitigation plan, while providing guidance template and technical assistance on request. • Requiring providing daily data updates for the number of positive cases, recoveries, tests performed, deaths, number of long-term care facilities with positive cases, number of persons under investigation and other information.
Testing	<ul style="list-style-type: none"> • Providing information about testing sites. • Developing a testing strategy to support broader testing and to prioritise testing of vulnerable populations and healthcare professionals/ Launching initiatives to test residents and staff in nursing care institutions. • Launching COVID-19 testing initiatives to quickly boost testing capacity. • Launching emergency rules to require hospitals test all residents before discharge to a nursing home. • Acquiring COVID-19 test kits. • Creating drive-through testing sites.

Infection preventions and control measures and guidelines	<ul style="list-style-type: none"> • Providing resources for skilled nursing facilities to help prevent, detect and prepare for COVID-19. • Creating COVID-19-dedicated web pages. • Creating strike teams to conduct testing in nursing homes when potential or positive COVID-19 cases are seen in residents or staff members • Providing guidance on emergency response (e.g., emergency teams, supplies and equipment) to overburdened nursing homes. • Establishing and educating staff regarding its COVID-19 response strategic plan.
Improving and increasing access to PPE	<ul style="list-style-type: none"> • Creating an online guidance for available PPE supplies. • Providing guidelines on universal masking and use of face coverings for residents, healthcare workers, staff and visitors in long-term care facilities. • Conducting a PPE train-the-trainer webinars. • Making major push for PPE to support healthcare workers in long-term care facilities, including masks, face shields and gloves. • Taking the lead in coordination between nursing homes and the emergency management authorities for distribution of PPE supplies. • Assembling a toolkit that provides state and best practice guidance for PPE. • Creating a PPE supply hotline informing nursing homes when supplies become available. • Assembling a PPE wholesale supplier registry public listing. • Establishing PPE reporting portal to monitor PPE levels. • Establishing a COVID-19 management team to coordinate and optimise healthcare resources.
Minimising potential COVID-19 transmission in health and other care settings.	<ul style="list-style-type: none"> • Decontaminate hands with alcohol-based hand rub (ABHR) for all staff, patients and visitors when entering and leaving areas where patient care is being delivered. • Wherever possible, patients, staff and visitors need to use disposable, single-use tissues to cover the nose and mouth when sneezing, coughing or wiping and blowing the nose – used tissues should be disposed of promptly in the nearest waste bin. • Also, tissues, waste bins (lined and foot operated) and hand hygiene facilities should be available for patients, visitors and staff

1. Cleaning and disinfection

Evaluation surface and air contamination in relation to SARS-CoV-2 during the COVID-19 pandemic revealed that surface contamination was detected on a range of items. Computer keyboards, chairs and alcohol dispensers had the highest proportion of positive/suspected SARS-CoV-2 samples (Zhou *et al.*, 2020b). The environment around patients with COVID-19 is widely contaminated. Therefore, basic environmental hygiene and disinfection measures should be put in place (Wu *et al.*, 2020a). Islam *et al.* (2020) reviewed global COVID-19 infection prevention and control (IPC) guidelines put together by organisations such as the WHO, the US Center for Disease Control and Prevention (CDC), and the European Centre for Disease Prevention and Control (ECDC) and concluded that in all guidelines alcohol-based hand sanitisers (ABHS) have been prioritised whenever available. To reduce room

contamination in hospital settings, all of the guidelines recommend routine cleaning and disinfection of surfaces using disinfectants. The Chinese guidelines also recommend the use of aerosol disinfectants using an air steriliser and pressure steam sterilisation. Guidelines from Australia, China and the United Kingdom recommend incinerating or sterilising patients' clothing, bedding and utensils (Islam *et al.*, 2020). Wu *et al.* (2020a) demonstrated the effectiveness of disinfection. However, the study suggested that environmental surface disinfection should include wiping in an "S"-shaped motion and that surfaces should not be re-wiped once they have already been cleaned. Additionally, the frequency of disinfection should be increased appropriately, to at least three times per day: twice during the day and once at night (disinfection should be undertaken at any time where there is obvious contamination). Moreover, cleaners should undergo ongoing training to ensure that they are qualified for their job.

Accordingly, CMS (2020) suggests offering decontamination systems for hospitals, nursing homes and other healthcare providers, in addition to distributing alcohol hand rub and COVID-19 cleaning solution to long-term care facilities when required. Providing cleaning services for long-term care facilities, as well as providing all environmental services staff with laminated daily and terminal room cleaning checklists, is suggested. These could be kept on carts and referred to in order to ensure that all cleaning steps have been completed (CMS, 2020). Knowledge maps can be used to provide knowledge of techniques, resources required and guidance on various cleaning and disinfection requirements (Brahmi *et al.*, 2013; CMS, 2020). Knowledge maps represent an excellent way to capture and share explicit knowledge in organisational contexts.

2. Minimising the potential of COVID-19 transmission in health and other care settings

According to the findings of Parra *et al.* (2021) and Nathavitharana *et al.* (2020), infection prevention efforts could benefit from the unprecedented amounts of data, information and knowledge on COVID-19 that are being generated and shared. Successful examples of the rapid intensification of infection prevention measures to decrease transmission in healthcare facilities should be emulated. For instance, the hospital authority of Hong Kong implemented a bundle of measures focused on early recognition, isolation, notification and molecular diagnostics for people who were being evaluated for COVID-19. They subsequently broadened the clinical and epidemiological criteria of surveillance as the outbreak evolved and intensified PPE recommendations for all healthcare workers (HCW) (face masks for all and N95 respirators for those performing aerosol-generating procedures), which appears to have resulted in no cases of HCW infection or nosocomial transmission.

Speel *et al.* (1999) define knowledge mapping as the process, methods and tools for analysing knowledge areas in order to discover features or meaning and to visualise these in a comprehensive, transparent form, such that the business-relevant features are clearly highlighted. Knowledge maps are created by transferring certain aspects of knowledge into a graphical form that is easily understandable compared to written and oral communication modes. Knowledge maps can be used to communicate this important information to patients and healthcare staff members and visitors. For example, patients, staff and visitors should be encouraged to minimise the potential for COVID-19 transmission by deploying knowledge maps to communicate good respiratory hygiene measures, including using disposable, single-use tissues to cover the nose and mouth when sneezing, coughing or wiping and blowing the nose – used tissues should be disposed of promptly in the nearest waste bin (CMS, 2020). They

can also help to visualise how hands should be cleaned (e.g., using soap and water, if possible, otherwise using ABHS) after coughing, sneezing, using tissues or after any contact with respiratory secretions and contaminated objects. Patients should be encouraged to keep their hands away from their eyes, mouth and nose (DHSC, 2020; CMS, 2020). This helps in minimising the potential for COVID-19 transmission in health and other care settings.

3. Training, education and communication

According to Anttiroiko (2021), an agile-adaptive approach, a policy of transparency in communicating risk, and citizens' voluntary cooperation were all critical to the success of South Korea's anti-contagion policy. It is important to incorporate the community into a response to a public health emergency (PHE), and to educate people about public health prevention standards, which can improve the ability to cope with a pandemic (Yang *et al.*, 2020). PHS (2021) states that organisations and employers must ensure that training in IPC measures are provided to all staff, including on the correct use of PPE (including a face fit check if wearing a filtering face piece (FFP3), respirator and the correct technique for putting on and removing (donning/doffing) it safely). Knowledge mapping can be used to communicate with families about pandemic-related responses such as testing as required (CMS, 2020). These knowledge-sharing techniques should be updated regularly with information and knowledge regarding regulations, infection control and PPE. Smart technologies can also be used to conduct virtual audits using video to verify cleaning protocols and the use of PPE in nursing homes, assisted living facilities and immediate care facilities. The creation of a website FAQ document for support on common questions and provision of waiver guidance is also recommended. These knowledge maps can also make use of artificial intelligence (AI) with imaging, clinical symptoms, exposure history and laboratory data, creating an algorithm with which to rapidly diagnose COVID-19 in patients. Al Hakim *et al.* (2020) also concluded that the support of technology through the use of AI can be expected to enable comprehensive, adaptive and objective knowledge mapping for organisations.

4. Reporting guidance and updates

Holmgren *et al.* (2020) noted that an effective pandemic response requires rapid, accurate information and knowledge sharing between hospitals and public health agencies. Advancing these capabilities requires information and knowledge to be reported and shared, including lab results and syndromic surveillance data, among various public and private health agencies. Such reporting requirements were originally intended to allow public health agencies to monitor and react quickly to potential infectious disease and influenza outbreaks. However, hospitals may experience technical or administrative barriers to this kind of reporting, and electronic hospital reporting to public health agencies has been inconsistent during the COVID-19. The resulting information and knowledge gaps can exacerbate the public health challenges in relation to identifying infection, quarantining and contact-tracing potentially infected individuals and can preclude a timely response in infected areas. Data characterising the extent of occupational infections in HCWs during acute and chronic epidemics are often lacking and subject to wide variability in reporting, which limits their impact (Elavarasan and Pugazhendhi, 2020; Vaishya *et al.*, 2020). Moreover, Nathavitharana *et al.* (2020) noted that transparency in data sharing and reporting will facilitate urgent action to replenish and sustain resources such as PPE and enable institutions to share and adopt successful infection prevention strategies. With regard to COVID-19, this reporting is designed to ensure that the information necessary to respond to the COVID-19 outbreak and to provide resources and support is available (CMS 2020; PHE, 2021). Knowledge maps can be used to share reports, updates and guidance

through authorities and local health officials, including daily updates regarding current staffing levels, the number of COVID-19 patients, capacity, supplies and the availability of equipment. Moreover, knowledge maps can also be used to share mitigation plans, guidance templates and technical assistance along with shared and collaborative reports (e.g., through sharing links or PDF).

5. Testing

The approach to initial management should focus on early recognition of suspect cases, immediate isolation and the institution of infection control measures. Moreover, the decision to discontinue infection control precautions for patients with COVID-19 should be made on a case-by-case basis in consultation with experts in infection prevention and control, and public health officials. Factors which should inform this decision include resolution of clinical signs and symptoms and negative results of reverse-transcription polymerase chain reaction (RT-PCR) testing for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from two sequential paired nasopharyngeal and throat specimens (McIntosh *et al.*, 2020). Knowledge of COVID-19 testing includes providing information about testing sites, developing a testing strategy to support broader testing and to prioritise testing of vulnerable populations and healthcare professionals, providing knowledge and information about acquiring COVID-19 test kits, in addition to developing a set of priorities and recommendations with to the aim of facilitating a rapid increase in testing for COVID-19, utilising all testing sites and platforms available (CMS, 2020).

Nathavitharana *et al.* (2020) noted that scaled-up testing in South Korea has helped limit the spread and the negative effects of COVID-19. The use of drive-through testing centres has enabled safe and efficient testing, while minimising the risk to HCWs and eliminating the possibility of cross-infection among people being tested. Therefore, knowledge mapping can be used to provide information and knowledge about testing sites and to launch initiatives to test residents and staff in nursing care institutions, whilst also allowing for the option of having a lab come to a particular location to undertake testing or obtaining supplies for on-site testing. Knowledge maps may also assist when launching COVID-19 testing initiatives to quickly boost testing capacity to ensure there is enough capacity and there are enough supplies to administer a significantly greater number of tests (CMS, 2020). PHE (2021) states that organisations and employers, including NHS Trusts, NHS Boards, Health and Social Care Trusts (Northern Ireland), Local Authorities, and Independent Sector providers, through their Chief Executive Officer (CEO) or equivalent, must ensure that testing strategies are in place with a local policy for the response if transmission rates of COVID-19 increase. Furthermore, according to La Marca *et al.* (2020), an understanding of the application and diagnostic performance of the different testing approaches for SARS-Cov-2 is essential in the fight against this pandemic.

6. Infection prevention and control measures and guidelines

Global IPC guidelines (e.g., the Department of Health, Australia, the Bureau of Disease Prevention and Control of the National Health Commission of the People's Republic of China, the CDC, the ECDC, Public Health England, and the WHO) have published COVID-19 IPC guidelines that have targeted health administrators, HCPs, or public health units to implement IPC measures (Islam *et al.*, 2020).

According to Anttiroiko (2021), containment and mitigation strategies are designed to slow the speed of spread of a virus by suppressing the outbreak and by slowing down the disease. As the coronavirus continues to spread and the testing rates vary from one country to another, public health officials should shift from a containment mindset to a mitigation mindset. According to Yang *et al.* (2020), the current main means of prevention and control are cutting off the route of transmission. However, such methods are very costly, involve the need to identify close contacts through various channels, and may lead to large numbers of people being isolated, even posing the risk of global economic downturn, currency devaluation in many countries and high mortality rates. Therefore, controlling and managing the COVID-19 outbreak requires the provision of resources for skilled nursing facilities to help prevent, to detect and to prepare for COVID-19 (CMS, 2020). Sharing knowledge regarding IPC measures in practice includes suspected source control, the use of PPE, rapid diagnosis, physical distancing, isolation, investigation and follow-up of close contacts. All the guidelines available around the world include administrative control, environmental control and PPE, and the guidelines in Australia, from the WHO, and the CDC (Islam *et al.*, 2020). IPC measures in healthcare settings include maintaining separation in space and or time between suspected and confirmed COVID-19 patients, educating staff, patients and visitors about standard infection control precautions (SICPs) and transmission-based precautions (TBPs), and prompt implementation of TBPs to limit transmission. They may also include restricting access for all but essential visitors to all areas of a healthcare facility, instructing staff members with symptoms to stay at home and not come to work until their symptoms resolve, in addition to planning and implementing strategies for surge capacity (CMS, 2020; DHSC, 2020). Knowledge mapping can be used to create web pages dedicated to COVID-19 information dissemination, with links to details of emergency response/strike teams (CMS, 2020). Thus, it may facilitate the knowledge sharing needed to enable early recognition or reporting of cases, early assessment or triaging of cases and the implementation of control measures.

7. Improving and increasing access to PPE

Preliminary data from the initial outbreak of COVID-19 in Wuhan suggested almost one-third of infected patients were health professionals (Li *et al.*, 2020). Given the high rates of transmission of COVID-19, there have been moves towards the use of universal PPE. Accordingly, Nathavitharana *et al.* (2020) noted that there has been a massive and rapid increase in the need for PPE globally because overwhelmed health systems have been having to care for large numbers of patients with suspected or confirmed COVID-19. However, the acute shortage of PPE is a challenge and has resulted in an urgent need to embrace innovation in terms of infection prevention (Nathavitharana *et al.*, 2020). Due to the global shortages in the supply of PPE, almost all of the guidelines have revised their initial recommendations related to PPE use. Of the six guidelines reviewed by Islam *et al.* (2020), five recommend the reuse of PPE following the manufacturers' instructions. Alongside sufficient provision of equipment and clear guidance, knowledge and adherence to the appropriate use of PPE among health professionals is required. Adequate PPE is, therefore, of paramount importance in ensuring the safety of health professionals working on the frontline, particularly those participating in aerosol-generating procedures (AGPs) (Bhamra *et al.*, 2021). Researchers widely believe that mortality would be reduced if the medical supply and PPE supply chains were protected (Swanson and Santamaria, 2021). Therefore, both the appropriate use and availability of PPE are imperative components in building a defence barrier against a highly infectious and potentially fatal virus (Yang *et al.*, 2020; Al-Hity *et al.*, 2021).

Nathavitharana *et al.* (2020) highlighted the potential for innovation and knowledge sharing to address PPE shortages, in turn enhancing HCWs' safety in the current COVID-19 pandemic. Contingency planning for PPE stock shortages is also important. However, providing solutions for the shortages in the supply chain for one-time-use PPE is extremely complex. Solutions include the use of smart communication channels to improve supply chains and stock management, bespoke production of PPE to meet shortfalls, along with the least preferred option, namely the use of sterilisation or high-level disinfection for PPE reprocessing (Rowan and Laffey 2020; Parra *et al.*, 2021). Therefore, the use of smart software and networking with various distribution channels is recommended to meet shortfalls in PPE and infection prevention and control (IPC) methods.

Knowledge maps can be used to create online PPE, employment and material resource guides for providers to enable them to find available supplies, disinfectants, PPE and employer/employee guidance. They can also be used to provide guidelines on universal masking and the use of face coverings for residents, healthcare workers, staff and visitors in long-term care facilities (CMS, 2020; Parra *et al.*, 2021). A major push is required in relation to PPE to support healthcare workers in long-term care facilities. Moreover, it can take the lead in coordination between nursing homes and the emergency management authorities for the distribution of PPE supplies.

Conclusion and recommendations

The ability to manage the COVID-19 pandemic is contingent upon the ability to effectively manage its knowledge resources. This implies the ability to correctly capture, share, apply and use the available knowledge resources to enhance decision-making (Rialti *et al.*, 2020). Balaid *et al.* (2013) noted that the most important responsibilities of KM are to envisage knowledge for knowledge seekers. Given the novelty of the COVID-19 disease, sharing other people's experiences of robust and clear practical procedures is ideal to familiarise healthcare professionals with COVID-19, especially in terms of hands-on best practice. The cost of not investing in effective knowledge management techniques, including knowledge mapping, is now widely apparent in the management of the outbreak of the pandemic (Rialti *et al.*, 2020). Knowledge maps illustrate relationships between procedures, concepts and competency and provide easy and effective access to knowledge sources (Watthananon and Mingkhan, 2012). Therefore, a knowledge map visualises the knowledge flow throughout the enterprise and helps to steer both tacit and explicit knowledge (Balaid *et al.*, 2013). Knowledge maps do not provide but rather indicate tools for knowledge and, thus, "knowledge maps are guides, not repositories" (Davenport and Prusak, 1998). Rapid scaling-up of diagnostic testing capacity, as well as bundles for cleaning, infection prevention and disinfection interventions, including universal masking and drive-through testing, could help to address PPE shortage issues, minimise disease transmission in health and other care settings, as well as safeguarding HCWs and the patients they serve in the current COVID-19 pandemic.

Knowledge maps are excellent ways to capture and share explicit knowledge in organisational contexts. Therefore, knowledge mapping using various graphical presentations of text, stories, models, numbers or abstract symbols between map makers and map users offers various opportunities to help to tackle COVID-19. Using knowledge mapping techniques allows large and complex sets of knowledge resources to be acquired and navigated more easily (Balaid *et al.*, 2013). This is especially important for managing COVID-19 due to the need to manage huge amounts of data from mobile applications, official websites, social media, virtual communities, instant messaging and social bookmarking (Nathavitharana *et al.*, 2020). Thus,

using knowledge mapping techniques in order to manage and share knowledge related to COVID-19 can enhance the arrangement and implementation of necessary control measures to avoid the further spread of the virus and tackle the impacts of the pandemic.

This study has developed a concept knowledge map for managing the COVID-19 pandemic, identifying seven areas of critical knowledge that decision-makers should be aware of. The findings indicate that knowledge mapping related to the COVID-19 pandemic has the potential to improve planning, treatment and control of the pandemic, and to enhance decision making. This study concluded that knowledge mapping related to COVID-19 assists in reducing and minimising the risk of transmission of COVID-19 in hospitals, healthcare settings and other care settings. It also provides information about testing and enhancing testing capacity. It improves and increases access to PPE. It enhances infection control measures by sharing necessary information about strike teams' roles in order to provide on-site medical triage, supplies and equipment to overburdened nursing homes in order to slow the spread of the virus among the most vulnerable in the population. It facilitates and supports reporting, training, education and communication, in addition to enhancing and enabling proper cleaning and disinfection processes.

This study fills the gap in the existing literature and contributes to concept mapping and the sharing of knowledge by identifying and evaluating critical knowledge areas for managing the COVID-19 pandemic and preparing for future emergencies. With the seven critical knowledge areas revealed, it provides explicit representation of know-how for managing the COVID-19 pandemic which facilitates access to COVID-19-related knowledge for various decision-makers. The knowledge mapping approach is perceived to improve and enhance knowledge management both within an organisation and externally with stakeholders and customers (Lin *et al.*, 2006).

The study advances the literature on knowledge management and builds a theoretical link with the management of public health emergencies. In addition, the findings support the theoretical position that knowledge maps facilitate decision-making and help users to identify critical knowledge areas easily and effectively. Utilising knowledge mapping offers two advantages in terms of managing and controlling the COVID-19 outbreak. Firstly, knowledge maps are represented in simple, clear, visual ways within the context of a knowledge management system. Secondly, the mapping methodology helps users to identify the most critical and easily available knowledge areas which can contribute to effectively controlling the pandemic.

The study offers valuable insights into key and critical knowledge areas decision makers need to be aware of in order to address the COVID-19 crisis effectively. For example, the results have demonstrated that effective knowledge sharing, and knowledge mapping can address PPE shortages, in turn enhancing HCWs' safety in the current COVID-19 pandemic. In other words, knowledge maps can be an effective knowledge-sharing tool for the dissemination of reports, guidance, and for collaboration in order to combine the conclusions of varying reports, thus helping to minimise the potential of COVID-19 transmission and to control the pandemic.

The paper contributes to both theory and practice in the fields of knowledge management and provides practical suggestions for the effective management of the COVID-19 pandemic. This

is the first study to identify the critical knowledge areas for managing COVID-19. This study has further implications in terms of enabling a discussion of the new paradigm of emergent knowledge mapping strategies for public health emergencies.

Encouraging and promoting work within and between multidisciplinary health professional teams is recommended in terms of developing strategies and policies that are shared by healthcare stakeholders. Table 6 sets out the implications for decision-makers and KM practitioners within public and private sector organisations in order to encourage them to rethink and act.

Table 6: Implications for decision-makers and KM practitioners within public and private sector organisations

Implications	Recommendations for decision-makers and KM practitioners
Using smartphone for knowledge detection	Smartphone is a ubiquitous tool that leverages the power of the internet like no other. It provides the ability to directly reach and engage with a significant proportion of the world's population in near real time, which has immense potential for addressing COVID-19 outbreaks via rapid detection. Therefore, more efforts need to be directed towards unpacking smartphone potential through efficient use and rapid detection of real time big data.
Epidemiological information sharing platforms	More effort and focus need to be directed towards supporting epidemiological information sharing strategies. Epidemiological data must be gathered through a steady and reliable approach, and establish a multi-department dynamic information sharing system, which will effectively and comprehensively improve the ability of medical institutions in metropolises for epidemic prevention and control.
Multi-department monitoring platform	Governments need to establish a multi-department platform to facilitate dynamic information monitoring, to improve the ability to prevent and control the virus spread.
Public engagement	Public-private-academia collaboration is necessary and is seen as a key to build and implement more efficient tackling strategies. Therefore, creating an open platform for sufficient use and share of data is required.
Knowledge discovery/ extraction	COVID-19-related data and information are unstructured, wide ranging in complexity, length and use of technical terminology, making knowledge discovery more challenging. Therefore, a number of text analytical tools that can facilitate a unique opportunity to extract critical knowledge from textual data sources and archives are required.
Knowledge creation	Provide and support unconventional and mature data storage, management, analysis and visualisation tools and techniques needed for extracting knowledge from a huge amount of data such as in the case of COVID-19.
Local-citizen-driven strategies	KM practitioners need to take into consideration the importance of the tacit local knowledge of the regional citizens as it has a great impact on their social behaviours.
Healthcare systems knowledge capturing	Healthcare systems need to facilitate the necessary software packages, and intelligence and analytical capabilities systems for data mining and knowledge capturing.
Increase collaboration	Managing COVID-19 knowledge requires collaboration between various bodies, sectors and departments. Therefore, there is a need for cross-sector collaboration to capture and share best and worst practices related to managing the COVID-19 pandemic.
Training	It is necessary to train doctors and healthcare practitioners to enable them to effectively manage real clinical challenges related to COVID-19. Thus, it is essential to provide them with as much updated knowledge as possible.
International collaboration	Partnership with foreign business with the same issues will accelerate the project. Therefore, a joint international effort is advisable to face the COVID-19 fallout and establish pathways for crisis management.

Using the Cloud for knowledge sharing	Smart strategies, such as the cloud is considered a game-changer in these times of uncertainty for many organisations. Therefore, cloud-based knowledge should be used for knowledge sharing and transfer through various channels in real time.
Digital transformation	In response to COVID-19, organisations have adapted rapidly. Digital transformation is becoming a norm; however, many productivity and security issues and concerns are still arising and require robust addressing strategies.

While the study contributes to the area of inquiry, it also has certain limitations. The study considered only journal articles and government reports published between December 2019 and April 2021, and only those written in English; these factors may have led to the exclusion of useful sources of information. Book chapters, books, conference papers, and unpublished works were not considered. The study was carried out following a thorough review of the literature but further studies could usefully be carried out by involving public health sector stakeholders. Additionally, it would be informative to explore empirical studies focusing on knowledge mapping within the context of the COVID-19 pandemic on a global scale. This would help to identify similarities and differences in the responses in developed and developing countries. This could lead to the generation of benchmark data and guidelines on best practices in terms of mapping COVID-19 pandemic-related critical knowledge areas.

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